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SHORTAGE OF SCHOOL SCIENCE TEACHERS

THE Barlow Committee asked the universities of Great Britain to double their pre-war output of science graduates by 1955, and they had almost done so by 1952. But in spite of this, there is a grave shortage of science teachers in schools and a serious decline in the academic quality of those presenting themselves, suggesting that the foundations of the educational structure for training science graduates are unsound.

The Incorporated Association of Head Masters, consisting of the heads of all boys' or mixed public and grammar schools in England and Wales, asked its members for particulars of their science staffs in July 1950. It received replies from four-fifths of their schools, employing 3,065 science teachers. In these schools, 193 science posts were unfilled ; in 48 schools a science subject had been dropped from the curriculum because it had been impossible to find anyone to teach it. Perhaps the shortage of science teachers might have been at its worst in 1950, because 'sixth forms' were already twice their 1939 size, while the additional number of teachers expected from the increase in numbers at the universities had not yet reached the schools. But the experience of head masters in the next two years suggested that the position was getting worse rather than better ; so, in July 1952, the Joint Four, which is the name given to the association of heads and assistants of public and grammar schools in England and Wales, undertook another survey. Three-quarters of the schools replied ; 49 posts in boys' and mixed schools and 116 in girls' schools were unfilled. Again, 145 science posts for men and 128 for women vacant in September 1952 were advertised between May 30 and July 25. It is unlikely that any of these vacancies has been filled ; no teacher already in a post could apply, as notice must be given by May 31 to be free to go to a new school in September ; and the few scientists at the university seeking their first teaching posts in September would have been engaged before the previous June. Thus some two hundred and fifty posts for science teachers in Britain will remain vacant for the whole of the present school year ; for if any of the above September vacancies are filled in January 1953, it will only be by creating a vacancy in another school. So some 190 vacant posts in boys' and mixed schools in 1950 has become between 50 and 140 in 1952. The shortage of science teachers in these schools persists, and it is pertinent to add that it leads to a continuous movement of science staff from one school to a better post in another. Nowadays, it is common for five out of a science staff of six to leave a school in the course of five years, so that even when no post is unfilled there is little continuity in the science teaching in the school. The position in girls' schools in Britain is even more serious, for 120 posts remain unfilled, which is one-fifth of their vacancies. Also it is well-nigh impossible to get teachers for girls' schools qualified to teach the 'science sixth', and university departments of

education are not receiving women science students of adequate attainments. So the cessation of the supply of women science graduates is within sight, since girls' schools will shortly be unable to train girls up to the standard for admission to the science faculties of the universities.

There has also been a decline in the qualifications of science teachers since 1939. Here it should be pointed out that high scientific attainment at the university does not necessarily imply ability as a teacher. The survey conducted by the Incorporated Association of Head Masters in 1950 claimed that one-fifth of the science teachers in boys' and mixed schools in Britain were not properly qualified for the work they were doing. In 1952 the survey made by the Joint Four, when the increased size of the universities had had time to increase the supply of science teachers, reveals a similar state of affairs: only 39 per cent of the science teachers taking up their first posts in September 1952 had first- or second-class honours degrees, compared with an average of 55 per cent in the schools before the War. In 1949, the Cambridge University Appointments Board was told of 400 vacant science posts. Before the War it would have filled 100; probably another 50 would be filled by Oxford and the remaining 250 by the other universities of Britain. But in 1949 Cambridge could fill only 59 of these science posts, and in 1950 only 11 Oxford science graduates out of a possible 213 took up teaching; none of them had a first-class honours degree and only three had seconds. It is clear that the schools are not getting back as teachers anything like as many of the abler boys and girls as they did before the War—and certainly not a fair share of them, if the schools are to do the work the nation expects of them.

This decline in scientific quality of science teachers is confirmed by the facts at individual schools. One leading State grammar school, with a distinguished list of academic successes making its vacancies very attractive, has had five chief science masters since 1942. The same school lost its second chemistry master, who went to another well-known grammar school as chief science master. His post was advertised three times; there was no applicant. The vacancy was temporarily filled by a pass-graduate who was giving up industrial chemistry at the age of forty-five and taking up teaching; after three years he is still holding the post. Of course, if good results are being obtained, then the authorities must congratulate themselves on having a good teacher—pass degree notwithstanding. In 1950 a well-known grammar school in a large city in the south of England had four first-class honours graduates on its science staff; in 1952 there is only one left, the chief science master, who is receiving a special responsibility allowance. These facts illustrate the drop in academic standing of science teachers in Britain since 1939. This decline in quality might well lead to a drop in the level of attainment of science specialists in the schools, so that fewer will gain admission to the universities. The universities in turn will produce fewer science graduates, and fewer science teachers than ever will enter the schools. We shall then have slipped back to the position which existed in 1900, when most science graduates started their science at the university, and the fruits of forty-five years hard work, by which the schools laid the foundations and the universities concentrated on the advanced work, will have been thrown away. One further fact underlines the precarious condition of school science. Too great a proportion of the good science teachers are more than fifty years old, so that the schools will lose most of them in the next ten to fifteen years.

What are the causes of this deplorable state of affairs? First, since the War we have tried to enlarge the universities, the Scientific Civil Service, the industrial research laboratories, the medical services, and the schools. Is it not possible, and even likely, that we are not producing, and never can produce, enough scientists to meet all these needs? Secondly, the salary of science teachers is too low. Before the War, a science teacher got £480 per annum—about the same as a university lecturer (£500 per annum) and about the same as he could get in the Scientific Civil Service or industry. To-day a science teacher gets £766 per annum, while a university lecturer gets £1,100 per annum and family allowances; and the Scientific Civil Service and industry are on similar scales. The science teacher's salary has not increased at the same rate as salaries in other occupations open to him. Before the War, the salaries of science teachers were determined by a separate Grammar School Burnham Committee, where the particular interests of all grammar school teachers received proper consideration. This separate Committee was abolished by the 1944 Education Act, and now the salaries of teachers in all types of school—nursery, primary, secondary modern, secondary technical and grammar—are settled by one Burnham Committee, in which grammar school teachers are in a minority. Their interests have received insufficient attention, because the majority of teachers on the Burnham Committee have failed to appreciate the importance of the grammar school in the national system of education. Finally, before the 1944 Education Act, there were two types of school, namely, elementary schools and grammar schools, and they were administered quite differently. Now all schools are administered in the same way; and unfortunately most local education authorities are administering all schools as they formerly administered elementary schools, in which the seat of authority was at the education office. Head masters and assistant masters feel that they have no longer the authority and freedom to do their work efficiently. They resent this loss of freedom, which is against the interests of their pupils and produces a sense of frustration, and is causing teachers to leave State grammar schools for independent schools, where both the salaries and working conditions are better.

The shortage of science teachers and the decline in their quality must be given careful consideration at the highest government level. The resources of scientific man-power and their most effective use require reconsideration, with full recognition of the claims of the public and grammar schools. It cannot be too strongly emphasized that these schools occupy

the key position in the professional life of Britain. They are the source from which the nation recruits not only its university students, but also the majority of other professional men and women, including the teachers in the primary and secondary modern schools. If the standards in the public and grammar schools be allowed to fall, this will in due course be reflected in the whole professional and industrial life of the community, with all this means for our standard of life.

The present position is that the number of suitably qualified graduates in science is strictly limited, and one profession, namely teaching, which occupies a fundamental place in the supply line of scientific men and women, is experiencing a serious shortage. If the work of technical colleges is expanded and a new technological university is opened, where will the additional staff come from? Some school science teachers are already being attracted to the technical colleges by improved salaries. It is therefore pertinent to ask whether the Scientific Civil Service and industry could economize in their use of scientific workers.

Secondly, the salaries of science teachers (and that of all grammar school teachers) should be made comparable with those offered by the universities, the Scientific Civil Service and industry. The present Burnham salary scale continues until March 31, 1954. If by that time the salary position in such schools has not improved, the present system of one Burnham Committee for all types of schools will have failed, and a separate Burnham Committee for grammar schools should be re-instituted, parallel with the separate committees both for technical colleges and for teachers' training colleges already in existence. Finally, every effort should be made by the Ministry of Education, by professional associations of administrators and of teachers, and by public opinion to induce local education authorities to restore to the grammar schools the working conditions they enjoyed before the War,

To sum up, there is at present in Britain a shortage of grammar school science teachers, and their scientific qualifications are below pre-war standard. The situation will get progressively worse and lead to a lowering of our standard of life unless prompt measures are taken. In its post-war schemes of expansion, Great Britain over-strained its resources of scientific manpower, with the result that science in the grammar school is suffering. The position warrants a survey at the highest level of the utilization of science graduates in Britain.

A PHILOSOPHY FOR MODERN MAN

The Conduct of Life

By Lewis Mumford. Pp. ix+342. (London: Secker and Warburg, Ltd., 1952.) 21*s*. net.

THIS book completes the series which Mr. Lewis Mumford commenced with the publication of "Technics and Civilisation" and continued in "The Culture of Cities" in 1938, and in "The Condition of Man" in 1944. In this final volume the reader is given the philosophy which inspired the earlier trilogy and which gives unity to the whole ambitious project. For two decades Mr. Mumford's thought has matured, as may well be seen by comparing the final volume with two other slighter books, "Faith for Living", written in response to the challenge of the early summer of 1940, and "Programme for Survival", provoked in 1946 by the menace of the atomic bomb. These two books contain, indeed, the core of Mr. Mumford's thesis and argument expounded at greater length and more maturely in the present volume. Mr. Mumford's claim that "The Conduct of Life" is, in fact, a preface to the earlier volumes of the series thus seems a little thin, but there is justice as well as logic in his contention that the full import of any one book cannot be grasped without an understanding of the other three. To some extent they overlap and are interdependent, and the admirable bibliographies are planned to be complementary so as to avoid overlapping.

Like "Faith for Living", "The Conduct of Life" is a confession of faith and a tract for the times. As such it is acceptable, where from a strictly philosophical point of view it might be found deficient. Even from that point of view it is a better and more mature book than "The Condition of Man". It is free from the tendency to dramatize and oversimplify the issues which in earlier books in the series masked the historical continuity and, especially with his predilection for dramatic captions and juxtapositions, frequently distracted or irritated the reader. The pattern of life clearly to be traced in those earlier books is here set forth in the context of some discussion, comprehensive but not exhaustive, of the final problems of man's nature, destiny and purpose, and the measures required to further that pattern are argued afresh in the light of the changes for the worse which have occurred throughout the world since Mumford began to write these books.

Mumford opens with a revolt against the idea of automatic progress through scientific advance and of the mechanical conception of life with its disregard for human personality. This seems to flow naturally from two brilliant chapters in "Technics and Civilisation" in which he discussed the assimilation of the machine and the reorientation of life on lines which gave full expression to human personality and made man once more the master and not the servant of the machine. Once again he diagnoses the present situation to show the challenge it offers to renewal, insisting on the need to concentrate all the resources our society possesses, all its present energies and vitality, and its funded values and ideas on the upbuilding and regenerative functions, in both the personality and the community. Such a process of renewal, he argues, holds our only hope of escaping catastrophe, and he then proceeds to analyse what is involved in such a reorientation to life. That analysis leads him to a discussion of man and his nature and the transformation of man, in which Mumford sets forth his ideas on ethics and religion much as he did in "Faith for Living". Philosophically, his argument seems somewhat superficial, but his plea for self-understanding and for a moral foundation is argued with a sincerity that commands respect even when agreement is only partial, and he gains strength as he goes on to delineate the basis for human development and to diagnose the obstacles which have to be removed or surmounted. On the fulfilment of man and the drama of renewal he writes with an assurance

that is never more fluent and convincing than when he expands his views on the need for balance and discipline—views which are similar to those Dr. K. E. Barlow set forth in "The Discipline of Peace". Here, even more than in his earlier books, Mumford reveals how much his thought has in common with Smuts's conception of holism, and his discipleship of Geddes is as marked as in a much slighter tract for the times, "The Social Foundations of Post-war Building", in which he expounded views which are set forth more fully here and in "The Culture of Cities". Mumford is never happier, too, than when he touches on the world of science: his book is supremely a sermon against extremism and rigid institutions in systems. He denounces as folly both the effort to increase productivity or output without regard to the effect on human personality, and a blind trust in the wisdom of the masses. The first step towards freedom, he argues, will be a new respect for the symbol, a purification and clarification of language itself, an abstention from the unclean slogans which are so cunningly employed by totalitarian regimes. "The death of the advertising agency and the propaganda bureau will be one of the surest signs of the birth of a new society."

Mumford pleads for thought, for the will and the means to direct the instruments we have created in the interests of life, so that we can contract them and bring them to a halt when they threaten that life. Discrimination and selection are essential elements in his programme, and he places in the forefront the cultivation of a sensitivity and a tenderness to human needs and personality to which the welfare State, no less than the totalitarian, is markedly indifferent. That is one reason for his sternness to those who reduce life to a rigid system: planning has its place, but strictly as the servant of man, and Mumford raises his voice against the barriers that have been erected in these years against the free interchange of opinions, the free rivalry of opposing beliefs, the free flow of ideas, as he does against subservience to all anodynes that impair our power of choice and judgment, whether the cinema, the television set, alcohol, tobacco or drug addiction. "The majority is probably wrong" might well be his reply to some of the slogans of to-day or to those who think modern man can do no wrong.

The development of evaluation and selection, of a constant discrimination between good and bad, as an inherent need of human life, is one of Mumford's three main criteria for an ethics of human development. Reverence for human life in all its manifestations is another: he examines at some length Dr. Albert Schweitzer's principle, which he commends without unreservedly accepting its theological connotation. Third is the acknowledgment of the purposive nature of all living processes and the conscious formulation of ideals, goals and plans as an essential transition of natural teleology into the development of man.

Mumford's distrust of rigid systems is a basic thesis of the book; more positively this is the affirmation of organic life in what he calls the principle of balance—a balance and harmony, sufficiently dynamic and comprehensive to nourish every kind of nature, to create the fullest variety in unity and to do justice to every occasion. It is this principle he finds incarnate in Schweitzer, and, following the latter's argument that no present form of science or political or religious organization can avert the disintegration of civilization, Mumford postulates, as the first condition of renewal, a withdrawal from society to gain the self-knowledge and concentration which are the prelude to effective action and to a balanced life characterized by health, poise and sanity, and renewed faith in the creative processes and in values and purposes that transcend past achievements and forms. What he advocates here is not asceticism as such but rather something akin to the wise administrator's practice of making time for creative thinking, free from routine duties.

In this way, Mumford suggests that the individual will regain the vision and initiative to make him an active and effective member on rejoining his group. Confidence in this prescription is derived by Mumford essentially from Clerk Maxwell's doctrine of singular points. "At these points, influences whose physical magnitude is too small to be taken account of by a finite being may produce results of the greatest importance. All great results produced by human endeavour depend on taking advantage of these singular states when they occur." Mumford believes in the possibility of the singular point, though he gives no indication as to how these points can be fostered.

In that possibility he finds the first reason for the faith and sense of purpose that he considers as essential for the development of man and the regaining of control over events. His second reason is in the sense of historic continuity to which his mature thought has led him. He starts with human life in its historic manifoldness and purposefulness: "Before every attempt to describe the world and life and time there stands an unspoken prologue: human history itself. . . . To understand the nature of man, accordingly, we must first of all understand this prologue". Mr. Mumford has now discovered not merely that man needs a religious as well as a moral view of the universe, but also that there are more primordial elements of human experience than matter or motion. Man lives in history and through history—in a sense he lives for history; and from this Mr. Mumford derives the faith that enables him to face the task of renewing civilization, even if, while recognizing the noble elements in the great world religions, he cannot entirely accept any of them. For him God is still in the making. There are occasional lapses in balance or judgment—as, for example, in the reference to Neville Chamberlain or the apparent bracketing of Schweitzer with Weston—but these do not impair the dignity of a courageous and inspiring book, a book which stimulates reflexion and self-examination and which, as a subsidiary merit, includes a select bibliography forming a reliable guide to representative books for further reading.

R. Brightman

HORMONES, CHEMOTHERAPY AND ANTIBIOTICS

Medicinal Chemistry

Chemistry, Biochemistry, Therapeutic and Pharmacological Action of Natural and Synthetic Drugs. By Prof. Alfred Burger. Vol. 2. Pp. xv+579–1084. (New York and London: Interscience Publishers, Inc., 1951.) 10 dollars.

THIS second and final volume of Prof. Alfred Burger's treatise follows the same pattern as the earlier volume, the review of which (*Nature*, 168, 438; 1951) contains general comments which are

applicable here also. In the main, this volume is concerned with synthetic drugs used in the chemotherapy of diseases caused by pathogenic organisms and with antibiotics. The author evidently wished his treatise to be fairly comprehensive and has included a description of vitamins and hormones; but he seems to have had difficulty in fitting these into his scheme. The vitamins were discussed in the first volume, although they have little relationship to the other classes of drugs dealt with there, whereas the present volume contains a chapter on hormones (mainly steroid) which seems a little out of place in relation to the other contents.

In his preface the author comments on the increasing activity in several fields during the year of publication, and he found it difficult to incorporate all the latest developments. This is inevitable with a rapidly advancing subject, and in the period which has elapsed since publication there have been further important developments. This applies especially to the adreno-cortical hormones, in connexion with which the past two years have witnessed much feverish activity culminating in their total synthesis; in improved methods of partial synthesis from more abundant plant and animal steroids; and in elucidation of some of the likely stages in their biosynthesis. In the field of antibiotics also there have been important advances, of which perhaps the most interesting is the recent claim to have established the structures of aureomycin and terramycin as hydronaphthacene derivatives (Woodward *et al.*, *J. Amer. Chem. Soc.*, **74**, 3708, 4976; 1952). The quest for new antibiotics seems to attract the big battalions. One learns from Prof. Burger's book that the first announcement of the discovery of aureomycin was made by forty-three authors, and that one of the earliest papers on terramycin appeared under the names of no less than eighty-five authors.

It is unfortunate that the discovery of valuable new therapeutic agents tends to be over-publicized, with exaggerated claims which lead to inevitable disappointment. This has happened many times in the history of therapeutics. Cortisone has been shown to be less generally efficacious in the treatment of rheumatoid arthritis than was originally thought; this and its undesirable side-effects have now led to the situation that the supply seems to have outstripped the demand. Recently the Americans have been considering imposing a ban on the use of chloramphenicol (chloromycetin), for although it has been used successfully in the treatment of rickettsial diseases, there have been indications that it may produce a dangerous condition of aplastic anæmia. In spite of such disappointments, there is probably every justification for Prof. Burger's statement (p. 658) that "the last fifty years of chemotherapeutic research have helped medicine more than the efforts of all scientists in the preceding 5000 years".

In addition to the chapters on hormones and antibiotics, the present volume contains chapters on essential amino-acids and fatty acids, dyestuffs used in chemotherapy, sulphonamide drugs, antimalarials, antitubercular and antileprotic agents (in both of which fields there have been subsequent developments), trypanocidal, amœbicidal and antifilarial drugs, organometallic compounds of arsenic, antimony, and bismuth, and antiseptics. There are available more extensive works on most of these subjects, but it is useful to have an excellent account of them all in one volume. An attempt has been made to present the views which have been advanced as to the mode of action of the drugs, and there is, for example, a chapter devoted to a discussion of theories of metabolite antagonism.

In its production this volume reaches the excellent standard set by Vol. 1, and there is a good index covering both volumes. There are a few misprints, such as "typtophan" (p. 581), and "persued" (p. 699). It is questionable whether "stereoisomerize" should be used as a verb (p. 627), but "grignardize" (p. 622) is an abomination. Exception could be taken to other points of detail; but as a whole the book is very readable and contains a wealth of useful information.

J. W. Cook

PLANT VIRUSES, OLD AND NEW

Plant Viruses and Virus Diseases

By F. C. Bawden. (Plant Science Books, Vol. 23.) Third, entirely revised edition. Pp. xvi+336. (Waltham, Mass.: Chronica Botanica Co.; London: Wm. Dawson and Sons, Ltd., 1950.) 6 dollars.

THE modern study of plant viruses involves the use of varied techniques and ramifies through much of the whole field of natural science. It is therefore a formidable task for any one investigator to collect together all the relevant information from such a wide field and present it in an intelligible and readable form. That Mr. F. C. Bawden has succeeded so well in his task speaks well for his grasp of the subject. During the past decade, with the development of new techniques and methods of approach to the problem, our knowledge of the plant viruses has expanded so rapidly that any books on the subject become quickly out of date. The author has realized this and in consequence has virtually rewritten the third edition of his book, adding a new chapter on quantitative methods of virus assay. There are now seventeen chapters, and they deal with external and internal symptoms of infected plants, methods of transmission, relations between viruses and vectors, mutation and interference between strains, serological relations, quantitative methods of assaying for viruses, their purification and chemical and physical properties, crystallinity, estimation of particle size, types of inactivation, taxonomy of viruses, physiology of host plants, control measures and speculations on the origins of viruses.

This list of contents shows how completely the subject is covered, though perhaps, by the time the next edition is called for, knowledge will have progressed far enough for a chapter on the multiplication of viruses to be added. One of the most interesting chapters is the last, in which the author discusses the origin of viruses. Like most plant-virus workers, he is struck with the appearance of new virus diseases which "are being described with an almost frightening frequency". On p. 321 he says: "it is probably to tolerant organisms we should look for the origin of our current pathogens". This brings up the question of the origin of these 'new' viruses, which is fundamental to the whole problem. It may not be too revolutionary, in view of the modern trend of virus work, to suggest that one explanation may be the transfer, usually but probably not always by insect agency, of cellular constituents from one organism in which they are not pathogenic to another one in which they are. We do not know how many instances of such "cellular constituents" exist, whether we

regard them as 'latent viruses' or merely as normal cell components of that particular host. The inference is that they are very numerous. The newly described latent virus of sugar-beet is a case in point. Transfer of this to the cowpea produces in outdoor plants a virulent disease. Other instances are the paracrinkle virus of King Edward potatoes and the latent virus of dodder.

Methods of detecting the presence of such latent or potential viruses are at present very crude and consist mainly of hit-or-miss trials with indicator plants. It is possible that the electron microscope will aid in this search, although the difficulties in interpreting the many virus-like particles seen in cells of apparently healthy plants are very great.

Mr. Bawden is to be congratulated on his book, which is clearly printed and illustrated with many excellent photographs. K. M. Smith

FUNGI FOR EVERYONE

The Molds and Man

An Introduction to the Fungi. By Prof. Clyde M. Christensen. Pp. viii+244. (Minneapolis: University of Minnesota Press; London: Oxford University Press, 1951.) 21*s*. net.

THIS book is written for "beginning students in mycology, whether amateur or professional". It would certainly be most useful for such people, but it may prove to be one of the few books which present scientific facts without strain to the non-scientific reader. The language is clear and the text most interesting of itself; many narrative novels have less power to hold the attention.

There are chapters on what fungi do and how they grow, on their reproduction and dissemination, and an appendix on their classification. Discussion of fungus partnerships with other plants includes lichens and mycorrhizas of orchids and forest trees. Partnerships with animals bring descriptions of scale insects and their fungus houses, ants and fungi, ambrosia beetles, the nitrogen cycle, and the fascinating behaviour of *Pilobolus* on horse dung. Plant diseases are treated with the importance they deserve, for Dr. C. M. Christensen himself lived mainly on corn-meal mush in the winter of 1916–17, when stem rust of wheat "emptied the breadbasket of North Dakota". Typical rust diseases of various food plants and fungi which cause heart rot in trees are the two subjects chosen to illustrate the whole. Fungi also destroy stored food-products—grain, butter, meat and eggs—and they rot wood, paint, fabrics and other materials. The section on parasites of micro-organisms and insects includes an account of 'snaring' mechanisms on some fungi which trap and feed on nematodes. It also describes several entomogenous species, and considers the possibilities of biological control of insect pests. Fungal parasites of fish, land animals and man expand the total of our awareness of fungi as enemies. On the credit side, fungi add to our food, either directly, as in the cultivation of mushrooms, or indirectly, to flavour, as in Roquefort or Camembert cheese. Enzymes and acids are now produced by mycological methods, while the fascinating development of penicillin and streptomycin is discussed in the text.

Dr. Christensen is an artist with words, and his book should bring mycology much more within the orbit of an increasing body of non-specialist but discriminating readers. Why, however, does he ration his book so sparsely of illustration? The few pictorial representations which do occur suggest that he may have a wit of delineation in addition to an ease of language. J. Grainger

TOWARDS THE ABSOLUTE ZERO

Low Temperature Physics

Four Lectures. By F. E. Simon, N. Kurti, J. F. Allen, K. Mendelssohn. Pp. vi+132. (London: Pergamon Press, Ltd., 1952.) 21*s*.

THE four lectures in this volume were delivered at the Royal Institution, London, in February and March 1950, but the opportunity has been taken during the interval to revise the text and to bring the subject-matter up to date. The references include papers published as late as the first quarter of 1952. Three of the lectures are by leading members of the low-temperature school at the Clarendon Laboratory, Oxford, and the fourth by Prof. J. F. Allen, of the University of St. Andrews.

Prof. F. E. Simon in his introductory lecture describes low-temperature physics as one of the most flourishing parts of modern science and gives a masterly general survey of the characteristic features, with particular reference to the guiding principle of the third law of thermodynamics and the fact that quantum laws cause all systems to approach a state of perfect order. Dr. N. Kurti discusses the temperature-range below 1° K., a region which has been explored for about ten years only and for the attainment of which, being below the lowest temperature obtainable with liquid helium, methods other than that of the standard method of gas liquefaction have been devised. The magnetic cooling method is fully dealt with, and nuclear paramagnetism, which is a very recent development, is shown to be a fruitful field of investigation for the application of extremely low temperatures.

The peculiar and most interesting properties of liquid helium, many of which are still not understood, are described by Prof. Allen, and finally Dr. K. Mendelssohn deals with that equally puzzling and perhaps in some ways related phenomenon, superconductivity. Discovered forty years ago and investigated both theoretically and experimentally in great detail since, a wealth of information has been collected; but there are grave difficulties in the way of a satisfactory explanation of the phenomenon. Dr. Mendelssohn suggests that what is missing is a new concept in physics, a new form in which the particles of matter can associate. He emphasizes the curious analogy between superfluidity in liquid helium and superconductivity, in both of which, at a certain temperature, the degree of order in the system suddenly increases; and he advances the idea of a fourth state of aggregation of matter, an ordering or condensation with respect to the momenta, in addition to the three states of aggregation of positional order.

The volume should prove most useful to honours students, to those intending to specialize in low-temperature physics and to more advanced physicists who wish to obtain a clear, authoritative picture of the present position of knowledge of low-temperature phenomena. S. Weintroub

Introduction to the Transfer of Heat and Mass

By E. R. G. Eckert; with an Appendix on Property Values, by Robert M. Drake, Jr. Pp. xiii+284. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 34*s*.

THE American edition of Dr. E. R. G. Eckert's excellent German text, enriched as it is by new sections and some fine interference photographs, is most welcome. The literature of the subject is so vast that there is need for a work such as this, which presents basic theory and established data but is chiefly concerned with depth of understanding.

The largest part of the book deals with heat transfer by convection. The starting-point is the flat plate in longitudinal flow, so that the student is immediately introduced to velocity and thermal boundary layers and acquainted with the factors which govern them. Extensive use is made of the approximate methods associated with the names of von Kármán, Pohlhausen and Kroujiline, which are simple and sufficiently accurate and which have the great advantage for the student of using physical, rather than exclusively mathematical, reasoning. Flow in ducts is treated later, as a case where the stream is all boundary layer. There is a good account of recent work on the analogy between heat transfer and friction.

Mass transfer is given less attention than heat transfer. The only case considered in detail is the transfer of water vapour between an air stream and a flat plate. A few pages devoted to generalizing the results so obtained would be a worth-while addition, contributing to the student's confidence in tackling other cases.

The treatment of radiation and radiative heat-exchange is concise and benefits from the fact that the author's own research has made important contributions to our knowledge of this aspect of heat transfer. D. B. SPALDING

Tables of the Error Function and of its First Twenty Derivatives

By the Staff of the Computation Laboratory. (Annals of the Computation Laboratory of Harvard University, Vol. 23.) Pp. xxviii+276. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1952.) 8 dollars.

IN various forms, at various intervals, and with various degrees of accuracy, integrals of the 'normal' (Gaussian) distribution function have been tabulated, mainly on account of its fundamental importance in statistical calculations. Nothing like the same attention has been given to the derivatives, although the demand for them has been increasing. They also enter into statistical calculations (for example, the Gram–Charlier series). They provide solutions of the equation of heat conduction or diffusion, are closely associated with the Hermite polynomials, and possess valuable orthogonal properties. After requests from various quarters these tables were prepared in the Harvard Computational Laboratory, under contract with the United States Air Force. It is claimed that, at any point, they give more derivatives or more decimals, or use a smaller interval, than other published tables.

Table 1 gives $\varphi_0(x) = \sqrt{(1/2\pi)}\exp(-\frac{1}{2}x^2)$, its integral (for completeness) and its first four derivatives. Table 2 gives derivatives from the fifth to the tenth. In these tables six decimals are given, at intervals of 0·004 in x, and tabulation proceeds until the values cease to be significant in the sixth decimal. Tables 3 and 4 give the succeeding derivatives, up to the twentieth. Here the larger values which occur for the smaller values of x are given to seven significant figures, but later values stop, as before, at the sixth decimal; the interval in these tables is 0·002. No reason is given for the rather unusual choice of intervals, and no special provision is made for interpolation, since the Taylor series is appropriate and not inconvenient.

An introduction gives an account of the main properties of the functions tabulated, an outline of the method of calculation, and an account of problems in which these functions have found application. Seven-decimal values of their zeros are also given.

W. G. BICKLEY

Copolymerization

By Turner Alfrey, Jr., John J. Bohrer and H. Mark. (High Polymers, Vol. 8.) Pp. x+269. (New York and London: Interscience Publishers, Inc., 1952.) 6.80 dollars.

COPOLYMERIZATION is the phenomenon of the synthesis of a macromolecule from two monomeric components, each of which is capable of polymerizing. Not all monomers exhibit this phenomenon, and in addition it is occasionally possible for copolymers to be formed when one of the components does not itself polymerize. Very occasionally it may happen that two molecules will form a copolymer and neither will polymerize separately. Copolymers are of great interest industrially—nearly all synthetic rubbers are copolymers because the necessary properties cannot be obtained with a homogeneous polymer made from one component only. But this volume is concerned almost wholly with the purely academic problems which arise in such processes. Most of the work on copolymerization has been induced by the addition of free radicals in the monomers, and the ionic mechanism of copolymerization has only been studied to a very limited extent.

The book presupposes some knowledge of polymerization mechanism, since this is dealt with in detail in other volumes in the series. The authors are so well known for their contribution to high-polymer chemistry that this whole book is a thoroughly critical and authoritative discussion of the reaction mechanism of copolymerization, the structures and reactivity of copolymers. The immense number of systems studied has added a very important chapter to our knowledge of relative reactivity radicals and thrown a new light on radical reactions. In spite of the specialist nature of the subject, the book will be of great interest to anyone interested in the mechanism of organic reactions. It is well produced, illustrated, printed and bound.

H. W. MELVILLE

Geometry and the Imagination

By D. Hilbert and S. Cohn-Vossen. Translated by P. Nemenyi. Pp. ix+357. (New York: Chelsea Publishing Co., 1952.) 5 dollars.

THE original German edition of this book, "Anschauliche Geometrie", was reviewed in these columns in 1933 (see *Nature*, 132, 369; 1933). This English translation, by P. Nemenyi, retains the fascination and enthusiasm of the original work, and should provide stimulus and inspiration to every student and teacher of geometry.

CONDUCTIVITY OF THE IONOSPHERE*

By Dr. W. G. BAKER
Amalgamated Wireless (Australasia), Ltd.,
AND
Dr. D. F. MARTYN, F.R.S.
Radio Research Board, Commonwealth Scientific and Industrial Research Organization, Canberra

MORE than seventy years ago, Balfour Stewart[1], and later Schuster[2], realized that the small regular daily oscillations of the compass needle were probably produced by electric currents in the upper atmosphere. The latter put forward a detailed quantitative theory, the 'dynamo theory', which attributed these currents to the regular daily (horizontal) tidal movement of conducting air across the magnetic field of the earth. Chapman[3] showed that the postulated conducting region should have a (height-integrated) conductivity $\int \sigma dh$ of $2{\cdot}5 \times 10^{-5}$ e.m.u.-cm. at the epoch of sunspot maximum, if the tidal speed in the conducting region was the same as that found at ground-levels.

When the ionosphere was experimentally discovered, about 1925, by Appleton, and by Breit and Tuve, it was reasonable to expect that the dynamo theory of magnetic variations would soon be confirmed. Unfortunately, as experimental knowledge of this region accumulated, it seemed clear that all the various ionized layers *D*, *E*, *F*, taken singly or together, had insufficient conductivity to give the necessary current intensities, if these were calculated according to Schuster's theory, which assumed that the velocities of the tidal winds in the ionosphere were the same as those measured at the ground. The calculated low conductivity of the ionosphere was due mainly to the earth's magnetic field, which impedes the horizontal flow of charged particles at the low pressures existing in the upper atmosphere, as first pointed out by Pedersen[4].

This deadlock in the application of the dynamo theory to the magnetic variations remained until 1936, when Taylor[5] and Pekeris[6] showed that the atmosphere could oscillate tidally in such a way that the wind velocities in the upper atmosphere were much larger than those at the ground. Previous investigators of atmospheric oscillations had assumed two special temperature gradients: (*a*) isothermal, with isothermal expansions (Laplace); and (*b*) fully adiabatic, with adiabatic expansions (Lamb). In these two special cases, chosen by Laplace and Lamb for mathematical convenience, the amplitude of the oscillations is independent of height; it is now clear, however, from Taylor's work, that these two cases are unique, for in the general case the amplitude tends to increase markedly with height. The fundamental physical principle involved in the general case appears to be that the horizontal *energy* flow tends to be uniform at all heights; this is proportional to ρu^2, where ρ is the air density, and u the speed of tidal motion. Thus u varies as $\rho^{-1/2}$, and may be expected to be some 1,000 times greater in the ionosphere than at the ground, if damping be negligible. In parallel with this theoretical development, the discovery of the large (1-km.) lunar oscillation of the *E*-region of the ionosphere by Appleton and Weekes[7] in 1939 appeared to provide an experimental vindication of the dynamo theory, since it could be interpreted as showing that the lunar oscillation at 120 km. was some 6,000 times that at the ground. However, Martyn[8] showed that this oscillation of the *E*-region was likely to be due, not to simple tidal rise and fall of the isobaric surfaces, but to the electrodynamic forces associated with the magnetic variations; this demanded much less amplification of tidal velocities—perhaps only 200. This view has been confirmed by Weekes[9], who finds no evidence of lunar tidal winds in the *E*-region of velocities greater than about 200 times those at the ground. It should be pointed out also that amplifications of 6,000 would lead, for the solar tide, to winds in the ionosphere of speeds approaching, or greater than, that of sound—an unlikely contingency, and one not envisaged in the theoretical work of Taylor and Pekeris.

Cowling[10] has made a careful study of ionospheric conductivity; his findings may be summarized by the statement that a tidal amplification of several thousands is required if the dynamo theory be valid, unless there are large numbers of negative ions in the *E*- and F_1-regions. More recently, Bates and Massey[11] have put forward strong arguments against the existence of negative ions in appreciable numbers in these regions. They conclude that the theoretical calculated conductivity of the ionosphere is less than 4×10^{-9} e.m.u.-cm., so demanding a tidal amplification of about 6,000.

In recent years, Martyn[12] has studied the observed amplitudes and phases of the lunar semi-diurnal oscillations in the heights and densities of the various ionospheric regions. He concluded that the phases were inconsistent with the view that the lunar magnetic variations were due to currents flowing in either the *E*-, F_1- or F_2-regions, if these currents flowed in the direction of the local electric fields. If this conclusion be accepted, then it must follow either that these currents flow in other regions, deficient in electron density but rich in negative ions, or that the currents flow in a direction markedly different from the electric fields. Bates and Massey (*loc. cit.*), after exhaustive investigation, have shown that it is extremely improbable that ions can exist at other levels, in numbers sufficient to give the necessary conductivity, so that the first-mentioned alternative is unlikely to be permissible.

Martyn[13] suggested in 1948 that the conductivity of the ionosphere may be enhanced if transverse (Hall) currents are prevented from flowing by polarization, along lines investigated first by Cowling[14] in connexion with the solar atmosphere. However, Cowling and Borger[15] considered that this suggestion would not account for the discrepancy, save perhaps in a narrow region near the magnetic equator.

It now seems clear that in spite of the early promise of Pekeris's theoretical calculations of high-level tidal amplitudes, and of Appleton and Weekes's measurements of *E*-region lunar oscillations, a major difficulty still exists, in that all the combined regions of the ionosphere have apparently insufficient conductivity (by the factor of 10 at least) to account for

* Substance of papers presented at the recent meetings of the International Scientific Radio Union and of the Mixed Commission on the Ionosphere, at Sydney and Canberra, Australia.

the observed geomagnetic daily variations according to the dynamo theory.

No satisfactory alternative to this theory exists, and it cannot be lightly abandoned, since it gives an excellent qualitative account of the magnetic variations. Moreover, an entirely different approach, by Ashour and Price[16], who have studied the induction of currents in the ionosphere, gives convincing support to the view that the average conductivity of the ionosphere is between 5 and 10×10^{-8} e.m.u.-cm., which would be adequate for the purposes of the dynamo theory.

Accordingly, we have examined afresh the fundamental principles involved in the production of electric currents in the ionosphere by tidal winds.

It is clear that the relevant conductivity cannot be σ_0, which is that appropriate for currents flowing parallel to the electric and magnetic fields, since horizontal currents must flow *across* the magnetic field in all but very limited portions of the globe. Another (lower) conductivity, σ_1, which is that appropriate for currents flowing parallel to the electric field, but transverse to the magnetic field, has been found inadequate quantitatively, as described above.

There exists another conductivity, σ_2, the Hall conductivity, which is relevant when the electric field, the current, and the magnetic field are all mutually at right angles, and when there is no hindrance (as by polarization) to the free flow of the direct (σ_1) current.

There is also still another effective conductivity, σ_3, that for currents flowing parallel to the electric field but transverse to the magnetic field, in circumstances where the Hall current is prevented from flowing by polarization.

Write

$$\omega_{e,i} = He/m_{e,i},$$

where H is the intensity of the geomagnetic field (gauss); $m_{e,i}$ are the masses of an electron and ion respectively; e is the electronic charge (taken as a positive number); $\nu_{e,i}$ are the collisional frequencies of an electron and ion with the air molecules, $\tan(\alpha,\beta) = \omega_{e,i}/\nu_{e,i}$; and N is the number of electrons (or ions) per cm.^{3}. Then the formulæ for these conductivities may be expressed in the following simple forms:

$$\sigma_0 = \frac{Ne}{H}(\tan\alpha + \tan\beta) = A(\tan\alpha + \tan\beta)$$

$$\sigma_1 = \frac{A}{2}(\sin 2\alpha + \sin 2\beta) = A \sin(\alpha + \beta)\cos(\alpha - \beta)$$

$$\sigma_2 = A(\sin^2\alpha - \sin^2\beta) = A \sin(\alpha + \beta)\sin(\alpha - \beta)$$

$$\sigma_3 = A \sin(\alpha + \beta)\sec(\alpha - \beta) \equiv \sigma_1 + \sigma_2^2/\sigma_1$$

(in the case of σ_2 it is necessary to specify the sense of the current by indicating that σ_2 is positive when H is directed along the positive x-axis and the electric field along the y-axis of right-handed axes).

Graphs of $\sigma_{1,2,3}$ (for $N = 1$) are shown in Fig. 1 at various ionospheric levels. In computing these, the atmospheric properties assumed were those adopted by Bates and Massey (*loc. cit.*); they incorporate the latest data derived from rocket measurements. In accordance with recent measurements by Shaw[17], ν_e was taken to be $2{\cdot}5 \times 10^5$ collisions per sec. at a height of 100 km. and $\tan\alpha/\tan\beta$ was taken as 1,650, in accordance with Tyndall's[18] measurements.

It is seen that σ_1 has two maxima, that at 140 km. due mainly to ions, at 75 km. to electrons. These maxima are relatively small, and they occur at heights where ionization is relatively sparse. σ_2 has one broad maximum, at 105 ± 35 km., so including all the ionization of the E-region; σ_3 has a pronounced sharp maximum at 100 ± 10 km. When account is taken of the known and probable electron densities at the relevant heights (Fig. 1, curve N) it is found that:

$$\int \sigma_1\, dh = 4{\cdot}5 \times 10^{-9} \text{ e.m.u.-cm.},$$
$$\int \sigma_2\, dh = 1{\cdot}45 \times 10^{-8} \text{ e.m.u.-cm.},$$
$$\int \sigma_3\, dh = 1{\cdot}2 \times 10^{-7} \text{ e.m.u.-cm.}$$

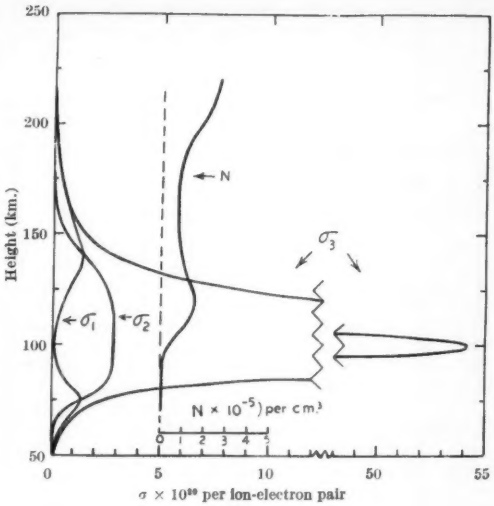

Fig. 1

Over the terrestrial sphere in general, the magnetic field is inclined to the horizontal, and to the 'dynamo'-generated electric fields. If we consider the ionosphere as a relatively thin sheet of conductive air enclosing the earth, and assume that *vertical* currents in the sheet are prohibited by polarization, then the important conductivities become σ_{xx}, σ_{yy}, σ_{xy} and σ_{yx}, the x- and y-axes running southward and eastward respectively. Here σ_{xx}, σ_{yy}, are the effective direct conductivities, and σ_{yx}, σ_{xy} the effective Hall conductivities, for horizontal electric fields in the south and east directions respectively. If χ be the magnetic dip angle, then:

$$\sigma_{xx} = \sigma_0\,\sigma_1/B, \qquad \{\to \sigma_0, \text{ as } \chi \to 0\}$$
$$\sigma_{yy} = (\sigma_0\,\sigma_1 \sin^2\chi + \sigma_1\,\sigma_3 \cos^2\chi)/B, \qquad \{\to \sigma_3, \text{ as } \chi \to 0\}$$
$$\sigma_{xy} = -\sigma_{yx} = \sigma_0\,\sigma_2 \sin\chi/B, \qquad \{\to 0, \text{ as } \chi \to 0\}$$

with $B = \sigma_0 \sin^2\chi + \sigma_1 \cos^2\chi$.

The variations of σ_{xx}, σ_{yy} and σ_{xy}, at the 100-km. level, are shown in Fig. 2 for latitudes (geomagnetic) from 0° to 90°. A logarithmic scale is used for the latitude Φ, since rapid changes take place near the equator. It will be noticed that at this height the horizontal Hall conductivity is some twenty times larger than the other horizontal conductivities over most of the earth. Within one or two hundred kilometres of the equator (magnetic), the Hall conductivity rapidly decreases, but the direct east–west and north–south conductivities rise to steep maxima.

It is readily found that a two-dimensional medium having direct conductivity σ_1, and transverse conductivity σ_2, has an effective conductivity $\sigma_1 + \sigma_2^2/\sigma_1$.

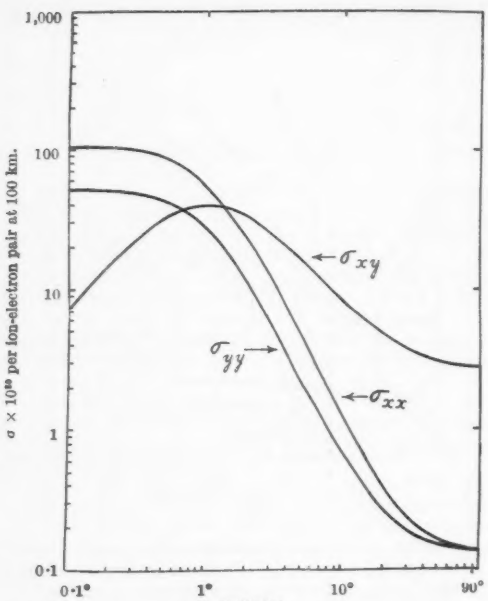

Fig. 2

In the case of the ionosphere, assuming for simplicity that $\sigma_{xx} = \sigma_{yy}$, the effective conductivity becomes $\sigma_{yy} + \sigma_{xy}^2/\sigma_{yy}$. However, although thin with respect to the earth, the ionosphere cannot be taken as infinitely thin, since σ_{xx} and σ_{xy} are variable within it. In order to assess its average conductivity, we assume that there is no height gradient of horizontal electric field; this assumption is justified by the high (σ_0) conductivity along the (nearly vertical) lines of magnetic force, which must be nearly equipotential lines. On this assumption the height-integrated effective conductivity becomes

$$\int \sigma \, dh = \int \sigma_{yy} \, dh \left\{ 1 + \left(\frac{\int \sigma_{xy} \, dh}{\int \sigma_{yy} \, dh} \right)^2 \right\}. \qquad (1)$$

At the magnetic equator, $\sigma_{xy} \to 0$ and $\sigma_{yy} \to \sigma_2$, so that:

$$\int \sigma \, dh \to \int \sigma_2 \, dh = \int \sigma_1 \, dh \left\{ 1 + \frac{\int \frac{\sigma_2^2}{\sigma_1} \, dh}{\int \sigma_1 \, dh} \right\}. \qquad (2)$$

(This expression is strictly accurate for the east–west conductivity at the equator; in this region the north–south conductivity degenerates to a somewhat higher value, namely, $\int \sigma_0 dh$ as shown above.)

In equations (1) and (2), the expressions in brackets have approximate numerical values of 12 and 29 respectively, with an uncertainty factor of about 2·1, depending on the unknown electron distribution between the E- and F_1- regions. Thus the effective conductivity of the ionosphere, over most of the earth, is some twelve times greater than that deduced by ignoring the Hall current, and near the magnetic equator is enhanced still further by an additional factor of 2·4.

Over most of the earth the currents are nearly perpendicular to the electric field, but are parallel to it near the magnetic equator. (There should therefore occur a rapid change in the phase of the daily electric field variations near this equator, a point which should have significance for the solar and lunar ionospheric variations.)

Equation (1) appears to account quantitatively for the high ionospheric conductivity necessary for the 'dynamo' theory, and would appear to justify the conclusion, after some seventy chequered years, that Balfour Stewart's 'dynamo theory' of the magnetic variations was well founded. Moreover, equation (2), which provides an additional enhancement of conductivity near the magnetic equator, is found to give a quantitative explanation of the anomalously large magnetic variations (the 'electro-jet') known to occur in these regions. (The latter conclusion has been tested by solving the dynamo equations for the spherical ionosphere, assuming the conductivity of equation (1) over most of the earth, and the narrow strip of higher conductivity at the equator.)

It appears that Martyn's earlier suggestion regarding the conductivity of the ionosphere is fully valid at the magnetic equator, and substantially valid over the rest of the earth; the earth's magnetic field reduces the conductivity by a factor much smaller than that deduced by Pedersen.

Over most of the earth, the current system should lie mainly between the 110- and 150-km. levels, the precise height distribution depending on the (relatively unknown) distribution of ionization and tidal velocities at these levels. However, near the magnetic equator the current system should be much more localized, Fig. 1 showing that it ought to flow in a shallow layer centred at 100 km. It is interesting to note that a rocket-borne magnetometer has recently been projected into the ionosphere near the magnetic equator by the U.S. Navy[19], and it is reported that the rocket passed completely through a current layer sufficiently intense to produce the observed diurnal magnetic variations at the ground; this layer was contained between the 93- and 105-km. levels.

We have discussed here the significance of our conclusions for the magnetic variations; if well founded, these conclusions are likely to have important application also to the theory of the regular solar and lunar ionospheric variations, and to the ionospheric variations associated with magnetic disturbance. These topics will be discussed elsewhere, in association with the detailed presentation of the above results.

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DYNAMO CURRENTS AND CONDUCTIVITIES IN THE EARTH'S UPPER ATMOSPHERE

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AND
W. A. BOWEN, JUN.
Naval Civil Engineering Research Lab., Port Hueneme, Calif.

EXPERIMENTAL evidence has been obtained recently concerning magnetic discontinuities in the *E*-layer of the ionosphere near the magnetic equator[1]. This communication deals with the conclusions which can be drawn from these results about electric currents and D.C.-conductivities in the *D*- and *E*-layers of the ionosphere and their relation to ΔH, the diurnal variation of the magnetic field on the earth's surface.

Rocket measurements. With magnetometers mounted in 'Aerobee' high-altitude sounding rockets[2], we have made three separate measurements of the variation of the earth's magnetic field with altitude from sea-level up to 105 km.[1,3]. An electronic magnetometer of the saturable 'Permalloy'-core type was used in each of the three rocket flights; in order to make its reading independent of the orientation of the rocket, it was designed to measure the scalar value of the total field rather than any one component. The small magnetic influences of the rocket were carefully neutralized; the magnetometer sensitivity was determined periodically by means of in-flight calibrations; and the output of the instrument was telemetered by radio to ground receiving stations. A detailed description of the apparatus is given in references 1 and 3.

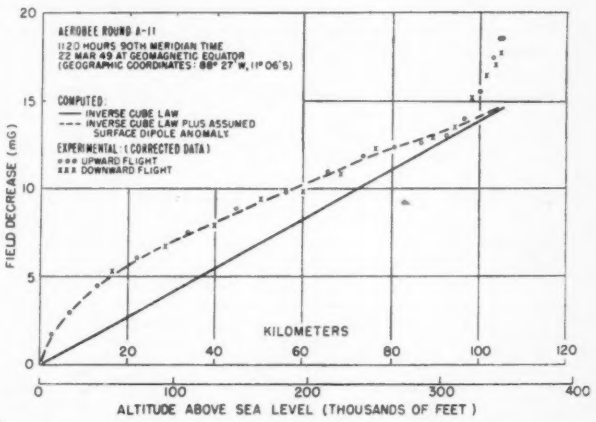
The initial attempt[3], conducted in April 1948 at the White Sands Proving Ground, New Mexico (geomagnetic latitude 41° N.), was designed mainly to test the instrumentation and the feasibility of the scheme. The decrease of the earth's field was found to be in excellent accord with the fall-off calculated from spherical harmonic analysis of the sea-level field[4]. No evidence either for or against a magnetic discontinuity could be established because of the smallness of the effect at this latitude.

Two further measurements were then carried out near the magnetic equator[1] (about 1,000 miles west of Huancayo, Peru) in rockets launched from the U.S. Navy seaplane-tender U.S.S. *Norton Sound*. The first rocket was fired on March 17, 1949, in the late afternoon, at which time ΔH is very small. Except for the effect of a small surface anomaly, the observed decrease of the magnetic field with altitude was in good accord with the inverse cube law; no detectable magnetic discontinuity was encountered.

The second rocket was fired near noon on March 22, 1949, close to the time of the maximum of ΔH, about 100 km. from the location of the first rocket launching. The deviation of the field from the inverse cube law (see graph) up to about 90 km. can be reproduced by means of a suitably *assumed* surface anomaly. An interpretation in terms of a current—although this has an *a priori* possibility—does not appear justified.

Between 93 km. and 105 km. we observe a very rapid decrease in the magnetic field amounting to $4{\cdot}0 \pm 0{\cdot}5$ milligauss. The agreement of upward and downward points is within 0·5 milligauss or better. We interpret this decrease as produced by a current flowing from west to east in a sheet of large horizontal extension which commences at 93 km. and extends to an altitude of at least 105 km. in a rather uniform manner. (The accuracy of the measurements is not sufficient to obtain the detailed current distribution within this altitude interval.) We have no direct experimental knowledge of the strength or direction of the current *above* 105 km., the peak altitude reached by the rocket (but cf. 4 below).

Experimental deductions. These experimental results allow us to draw some conclusions about certain electrical properties of the earth's upper atmosphere.


AEROBEE ROUND A-11
1120 HOURS 90TH MERIDIAN TIME
22 MAR 49 AT GEOMAGNETIC EQUATOR
(GEOGRAPHIC COORDINATES: 68° 27' W, 11° 06' S)
COMPUTED:
INVERSE CUBE LAW
INVERSE CUBE LAW PLUS ASSUMED SURFACE DIPOLE ANOMALY
EXPERIMENTAL (CORRECTED DATA)
UPWARD FLIGHT
DOWNWARD FLIGHT
FIELD DECREASE (mG)
KILOMETERS
ALTITUDE ABOVE SEA LEVEL (THOUSANDS OF FEET)

(1) They establish by direct experiment the existence of a current system which is presumably responsible for the exceptionally large diurnal variation of the earth's field observed at Huancayo.

(2) The location of the current is found to be in the lower portion of the *E*-layer of the ionosphere; this fact lends further strong support to the dynamo theory[5] originally proposed by Balfour Stewart[6] in 1883 to account for the production of the current system which was inferred by him from the diurnal variation of the earth's magnetic field.

(3) The results do not bear out the existence of any appreciable current in the *D*-layer such as had been proposed by Martyn[7]. (A similar conclusion has been reached by Bates and Massey[8] in quite a different way, namely, by showing in detail that the maximum negative-ion concentration, and hence conductivity, in the *D*-layer would be too low.) Further measurements will be required to establish with certainty the distribution with altitude of the currents responsible for the exceptionally large lunar effect on the quiet-day solar (S_q) diurnal variation at Huancayo.

(4) It appears that the current must drop to zero rapidly just above 105 km. (unless we assume a counter-current to flow at a higher altitude). We

* On leave from the Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Md.

reach this conclusion by comparing the amount of discontinuity—4 milligauss—with the sea-level variation of 2 milligauss observed at Huancayo. It is reasonable to suggest, therefore, that the electrical conductivity falls to zero rapidly above 105 km.

(5) The most striking feature of these results is the fact that the total current is confined to such a narrow range of altitude. We cannot account for this high value of current density ($2 \cdot 5 \times 10^{-10}$ e.m.u./cm.^{2}) if we assume in the conventional manner that the presence of a transverse magnetic field radically decreases the conductivity. At the magnetic equator the usual method of calculating the (west–east) D.C.-conductivity (parallel to the e.m.f. and transverse to the horizontal earth's magnetic field) leads to a value of 5×10^{-16} e.m.u. at the level of maximum electron density[9]. From the *observed* current, on the other hand, we can calculate an average conductivity of 10^{-13} e.m.u., using commonly accepted figures for high-altitude winds and the resulting e.m.f.'s.

(6) Thus the experimental value corresponds closely to 6×10^{-13} e.m.u., the value of conductivity calculated for the level of maximum electron density ($1 \cdot 5 \times 10^5$ per c.c.) in the absence of a magnetic field.

Hall effect. This discrepancy of almost a factor 1,000 between the observed and conventionally calculated conductivities can therefore be removed by ignoring the magnetic field.

It is well known[10] that this procedure is justified under suitable boundary conditions. In crossed electric and magnetic fields both ions and electrons will drift in the same direction (perpendicular to both fields), the electrons at a much higher speed. The resultant Hall current may set up a polarization sufficiently large to stop further current flow; once this transient Hall current ends and the polarization is established, any influence of the magnetic field on the conductivity parallel to the applied electric field is removed. Martyn[11] has suggested that this effect should be considered in calculating the conductivity of the ionospheric layers (although in the case of the *D*-layer at 75 km. the increase brought about by neglecting the magnetic field will be quite small). Cowling and Borger[12] have pointed out that, due to leakage, the polarization field may not build up sufficiently to keep a substantial steady-state Hall current from flowing and so result in only partial cancellation of the effect of the magnetic field. However, at the equator conditions may be favourable for almost complete cancellation, since the Hall current there flows perpendicularly to a horizontal magnetic field; hence a vertical polarization could be set up along a narrow equatorial strip where it would leak away only very slowly.

Conclusions. The results of the equatorial rocket measurements thus support the existence near an altitude of 100 km. of a layer of greatly increased conductivity, probably produced by Hall polarization. This finding is in accord with Hirono's[13] prediction of a narrow, highly conducting region at the equator; it may thus account for a substantial part of the so-called anomalous S_q variation at Huancayo.

Recent detailed measurements by Giesecke[14] of the latitude-dependence of the range of the diurnal variation ΔH have established the existence of a curve with maximum near Huancayo which is much more narrowly peaked (half-width 7°) than hitherto supposed; the main features of the curve probably persist all along the magnetic equator independent of longitude. Chapman has represented this 'abnormal' peak in a phenomenological way by superimposing on the normal dynamo current system (deduced from non-equatorial stations) an additional high-intensity current of small horizontal extension flowing only at the equator, which he terms 'electrojet'. So far no certain deductions have been possible about the dimensions, and particularly about the height, of the electrojet from sea-level observations of the magnetic elements. We cannot, therefore, exclude the possibility of interpreting Giesecke's data in terms of increased equatorial current produced by the increase in conductivity, plus the Hall polarization leakage currents. Hence the electrojet may not require any special physical mechanism, but may be understood purely on the basis of the dynamo theory.

It should be pointed out that the conclusions presented here are based on a single rocket flight, at only one location, on a disturbed day (*C*-index 1·8). It would be very desirable to repeat and extend these measurements of the Balfour Stewart currents in a series of rocket flights to higher altitudes, both on magnetically quiet and disturbed days, and also at various phases of the moon in order to establish the distribution of the lunar portion of the currents. The instrumentation has now been improved sufficiently to make it possible to obtain the detailed distribution of the current with altitude with considerable accuracy.

We wish to thank Prof. H. Alfvén, Prof. T. G. Cowling, Mr. W. R. Piggott, and in particular Dr. M. H. Johnson for valuable discussions. [Aug. 15.

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COLOUR TELEVISION

THE sixty-seventh science meeting of the Physical Society Colour Group, held on May 14, was devoted to a discussion on visual problems in colour television. Fortunately this followed immediately on Prof. W. D. Wright's return from the United States, where among his other commitments he had discussed and witnessed demonstrations of various American colour television systems. He was therefore able to give the meeting first-hand impressions of the very considerable developments in this field on the western side of the Atlantic.

The proceedings were opened by Mr. R. G. Horner, who gave a comprehensive survey of the more feasible methods at present available for producing a colour television picture. All these are based on the conventional system of interlaced scanning, the main differences between the systems at present under

discussion being in their colour scanning sequences, which fall broadly under three headings: (*a*) field sequential systems, (*b*) line sequential systems, (*c*) dot sequential systems. Of these, the first and third are actively in competition in the United States; so far, there has been no real evidence of success with the second system, which appears to embody the disadvantages of the first one without the compensating advantages of the third.

In the field sequential system the picture is scanned in a succession of red, green and blue fields, and, in order to reduce flicker, it is necessary to increase the field scanning-rate by approximately three times. As the colour-changes in this system take place at relatively low speeds, it is possible to produce them by the simple and cheap expedient of revolving synchronous disks containing red, green and blue colour filters in front of the television camera and receiver cathode-ray tube. However, due to the increase in field scanning frequency, an existing monochrome receiver would be unable to receive a colour transmission even in monochrome without considerable modification to its scanning circuits.

The dot sequential system involves the most rapid rate of change of colours, so rapid, in fact, that one school of thought considers the latest form to be a truly 'simultaneous' transmission of the three primary-colour signals. While this system involves the very difficult technical problem of colour-changing at a rate of several millions per second, it offers the great advantage of requiring no change in scanning-standards, and could therefore be grafted on to an existing black-and-white system and be received in monochrome on existing receivers. Mr. Horner explained that this 'compatibility' feature is very important in the United States, where more than ten million receivers are already in the hands of the public, and programme sponsors have to be assured of the continuance of their audience when changing over to colour.

At first sight it would appear necessary to transmit about three times as much information per second for a colour picture as for a monochrome one of the same sharpness. The amount of fine detail in the picture can obviously be reduced and exchanged for colour if it is desired to keep the rate of transmission of information (band-width) constant. To a certain extent this has been the procedure adopted for recent demonstrations of the field sequential system in the United States by the Columbia Broadcasting System. The loss of sharpness incurred has been partially recovered by a new receiver circuit development known as 'crispening', and very satisfactory colour pictures have been demonstrated.

In the latest form of the dot sequential system demonstrated by the Radio Corporation of America and Hazeltine, it has been found possible to recode the three electronic primary-colour signals to give a brightness component similar to that transmitted in existing monochrome systems, the colour information being transmitted by two 'colour-difference' signals which are analogous to the familiar two dimensions of the C.I.E. colour triangle. This has been called the 'by-passed monochrome' system. As the eye is insensitive to colour in fine detail, it is therefore possible to reduce the band-width (sharpness) of the two colour-difference signals. This manœuvre is one method of achieving what is known as 'the principle of mixed highs', and permits considerable saving in band-width without apparent loss of picture quality. Further band-width reduction is being explored by interleaving the colour signals with the monochrome signal, by a method which was originally a 'dot interlaced' system and more recently a 'colour sub-carrier' system. Two other American developments were referred to—the 'constant luminance' system and 'colour phase alternation'—which are refinements directed towards the reduction of spurious patterns produced by interfering signals and reduction of colour distortion.

Mr. Horner concluded his remarks by describing various solutions to the problem of changing the colours at the very high frequency necessitated by the dot sequential method. This problem is much less serious in the transmitter than in the receiver, where the question of initial cost and maintenance of the viewers' equipment is obviously an important economic factor. So far, the most successful solution appears to be the RCA tricolour cathode-ray tube. This tube contains three guns, the electron beams of which are brought into coincidence on a fluorescent screen consisting of a mosaic of triangular groups of red, green and blue phosphor dots, a total of some six hundred thousand being contained in the picture area. Between this and the electron guns, an apertured mask is accurately positioned. Each aperture centres on a group of three phosphor dots, the direction of arrival of the three beams being such that, after they have passed through the aperture mask, each beam can only excite one set of colour phosphor dots. This solution obviously involves the problem of the correct registration of the three electronic pictures on the screen of the tube. The experimental manufacture of these tubes by RCA is a major technical triumph, but many people feel that it is likely to be a very expensive design for production.

Following Mr. Horner's description of the various colour television systems, Mr. L. C. Jesty described and demonstrated some of the visual problems arising. First, with the field sequential system, the field scanning-rate has to be sufficiently high to eliminate flicker and 'colour break-up'. This was demonstrated by means of a variable-speed colour-filter disk rotating in front of a projector. With the disk running sufficiently fast to eliminate flicker, 'colour break-up' still remained and showed itself in two ways. If the viewer inadvertently moved his eyes, he saw a sequence of partially overlapping red, green and blue images. Experience has shown that the average person quickly learns to ignore this, and it is not considered to be a serious defect in the system. If an object in the picture moves rapidly across the screen, however, an effect is produced which cannot so easily be ignored. An exaggerated example of this was demonstrated by illuminating a wheel having white spokes with the projector and rotating colour-filter disk. In addition to the contrary rotation effect occurring at certain critical speeds of the wheel (as commonly seen on cinema pictures), some very striking colour patterns were produced by the spokes. A 'Kodachrome' transparency photograph of an actual field sequential colour-television picture of the wheel was then projected. This showed the same brilliantly coloured spokes, thus confirming the demonstration.

With the compatible colour sub-carrier system at present being investigated in the United States, the method of signal compression results in the appearance of a 'dot crawling' pattern on parts of the picture under certain conditions. In earlier experiments the band-width compression was achieved by simple dot-interlacing, which gave a theoretical improve-

ment equal to halving the band-width for the same picture-detail, but at the expense of four scanning fields instead of two for the transmission of all picture elements. The resulting dot crawling or 'twinkle' on the picture and the production of additional spurious patterns from objects containing certain types of fine detail were demonstrated to the meeting in an exaggerated form by a 16-mm. film which had been recorded from the receiver screen of an experimental dot-interlaced monochrome television system. In the latest American experimental colour receivers dot patterns are now practically invisible over large areas of uniform brightness and colour, due to improvements in the method of coding the colour information.

As a final demonstration Mr. Jesty showed some colour pictures which had been kindly prepared for him by Ilford Limited (Mr. Horner), demonstrating the principles of 'by-passed monochrome' and 'mixed highs'. Two colour pictures were shown side by side for comparison, one being a normal colour transparency projected on to a screen; the other consisted of a black-and-white photographic enlargement from the original colour picture, which was illuminated by projection from a special colour transparency. The latter had been prepared by re-photographing the original colour picture with colour-sensitive material, using a black-and-white negative 'mask' of suitable quality to cancel out the greater part of the brightness differences in the colour picture. It was seen that, when this second transparency was in focus and registered with the black-and-white enlargement, it was almost indistinguishable from the normal picture alongside it. The special transparency was then progressively defocused by adjustment of its projector lens, and with certain types of picture it could be thrown badly out of focus with no noticeable loss of picture quality. The projector lens mount had been previously calibrated in Mc./s. on the basis of the B.B.C. 405-line 3-Mc./s. picture standard. The demonstration showed that the colour components of the image could be defocused well below 1 Mc./s., so long as the brightness (black-and-white) component of the image remained sharp.

Mr. Jesty concluded his remarks by stressing the necessity for a proper appraisal of alternative systems by a team of average observers, due care being taken to ensure they do not become especially skilful in their judgment, thus losing their average status.

Prof. Wright then reported on his American visit. Of the various colour television demonstrations he had seen, the field sequential system is in the most advanced state, and has given the best picture quality. He felt, however, that the potentialities of the dot sequential system are greater, particularly with regard to band-saving techniques such as in the application of the 'mixed highs' principle and, of course, in 'compatibility'. He was inclined to query if any loss in absolute definition could be tolerated in exchange for the addition of colour. He was very impressed with the technical achievement in preparing the phosphor mosaics, and in locating the mosaics, aperture mask and the three gun electrodes in correct alignment in the manufacture of the RCA tricolour cathode-ray tube.

The American television engineers have completely absorbed the C.I.E. colour triangle and are applying it with ingenuity to their colorimetry problems. Doubts are, however, beginning to arise as to the relevance of the C.I.E. data to all their problems, and colorimetrists are already becoming aware of the impact of the ideas of electronic engineers. Much remains to be learned on the subjective aspects, and the work already done in colour photography is being carefully studied. The use of an illuminated surround to the picture is being actively investigated in one laboratory. An example of the direct application of trichromatic theory to colour television is to be found in the 'low flicker primaries' used in the Columbia Broadcasting System field sequential demonstrations. By the choice of a desaturated blue primary in the receiver, they have been able to increase picture brightness without increasing flicker. The range of reproducible colours is thereby diminished, but this does not appear to give any noticeable reduction in picture quality. Again, it is possible in principle to make colour transformations from one trichromatic system to another, by means of suitable electrical circuits, and it is proposed to take advantage of this by transforming the output signals of the red-, green- and blue-sensitive cameras at the transmitter, to give correct red, green and blue modulating signals at the receiver, without the need for devising cameras having partly negative spectral sensitivity curves.

A recent American development is the Lawrence–Paramount tricolour tube. The screen of the tube consists of a fine grid of coloured phosphor lines, and close to this and accurately registered to it is a mesh of parallel wires, alternate wires being connected together. There are in effect, therefore, two interlaced grids. By applying suitable potentials to these, it is possible to deflect the electron beam on arrival so that it excites the required set of colour lines.

Following the three introductory papers, the meeting was thrown open for general discussion. Several speakers raised points relating to methods of exchanging picture-sharpness for colour. The general conclusion seemed to be that the eye is more sensitive to luminance differences than colour differences in regions of fine detail, particularly in actual television programmes, where other overriding distractions are present. If it is necessary to show detail colour as, for example, in a woven fabric, the technique of the 'close up' is available and would deal very adequately with any such requirement.

Dr. J. A. Darbyshire discussed the secondary advantages arising from the addition of colour to a picture, and demonstrated these by projecting some of his own colour transparencies. Colour can add materially to the impression of depth in a picture. For example, the colour of distant objects is often modified by atmospheric effects. Colour differences make small objects in the picture more visible, thus giving an impression of greater sharpness, not directly related to 'resolving power'. It can produce an atmosphere or mood which increases the viewers' appreciation, as, for example, the difference in the same scene viewed in the daytime and at sunset. The effect of adapting conditions on the choice of white in a picture was discussed by Mr. H. G. W. Harding. With a colour television receiver it would be possible to adjust this for viewing by daylight and by artificial light. Mr. G. T. Winch described his binocular viewing experiments for the appraisal of artificial illuminants. This technique might be applied to determining the best colour balance for television pictures. It was certain that faithful reproduction would not be acceptable. Dr. W. S. Stiles directed attention to the latest American proposals for a compatible system, where the reduced-definition red and blue colour-difference signals are equal in band-width. Further

economies could be effected if the blue colour-difference signal were reduced in definition still further. The meeting having exceeded its time limit, the chairman was forced to bring to a conclusion a still lively discussion of an obviously interesting topic.

L. C. JESTY

OBITUARIES

Sir Charles Peers, C.B.E., F.B.A.

SIR CHARLES REED PEERS, born in 1868, will be principally remembered as chief inspector of ancient monuments in the Office of Works. Educated at Charterhouse and King's College, Cambridge, he received his architectural training in the office of Sir T. G. Jackson. Peers's principal interest lay in the historical side of his profession, and he was for many years architectural editor of the "Victoria County Histories". As such he was responsible for the description of a number of important buildings, among which the scholarly and lucid accounts of the cathedrals at Winchester and Peterborough may be noted. With this experience he was an obvious choice when an inspector of ancient monuments in the Office of Works was appointed in 1910. Three years later the Act of 1913 was passed and Peers became chief inspector. The next twenty years, apart from the interruption caused by the First World War, were spent in building up and directing the services required to give effect to the provisions of the Act.

The Act of 1913 empowered the Office of Works to take over buildings, other than churches in use and inhabited houses, in order to ensure their preservation. In carrying out this work, Peers's aim was to preserve what time had left without unnecessary additions or conjectural restoration. The success with which he pursued this conservative objective may be judged both from the numerous abbeys and castles for which the Ministry became responsible during his period of office, and also from the virtual cessation of the bitter controversy between the different schools of preservation, which had vexed the end of the nineteenth and the early years of the twentieth century. While it would be too much to claim that there is no criticism of the work carried out under his guidance, it is essentially a criticism of details; the main tradition which he founded is unchallenged.

Research was not a primary duty of the service established by the Act of 1913, but throughout his tenure of office Peers strove to promote the publication of works that would rouse interest in the buildings under his care. For specialists there were learned articles in scientific journals such as *Archæologia*, the *Antiquaries Journal*, and many others. For the wider public there was the admirable series of official guides to the monuments in charge of the Ministry, a series of which the larger part were from the hand of the chief inspector himself. On retirement from the Civil Service in 1933, his experience was made available to other bodies. He became surveyor of Westminster Abbey, and consulting architect to a number of important buildings such as York Minster and the Cathedral and Castle of Durham.

Peers was associated from the beginning with the work of the Royal Commission on Historical Monuments and became a commissioner in 1921. His connexion with the Society of Antiquaries was long and intimate; he served successively as secretary, director and president, and was continuously an officer from 1908 until 1934. His death has come at a time when the cause in which he spent his working life is firmly established and in good hands, a result largely due to the excellence of the foundations which he laid.

C. A. RALEGH RADFORD

Mr. S. R. Roget

SAMUEL ROMILLY ROGET died on November 17 in the way he would have wished, suddenly and while in full harness. In spite of his seventy-seven years, he was actively engaged, on a full-time basis, in work dear to his heart—the preparation of national and international glossaries on electrical and other technical subjects. His keen interest in this sort of work is, of course, well known; not only did he publish a "Dictionary of Electrical Terms", but also he kept up to date the famous "Thesaurus of English Words and Phrases" which was compiled by his grandfather, Dr. P. M. Roget, and first published in 1852.

Born in London in 1875, the great-grandson of a Genevese Protestant minister who came to England to be the pastor of a London Huguenot Church, Samuel Roget was educated at University College School. He studied mechanical sciences at Cambridge, and after a further year of experimental work at Cambridge went to the Woolwich works of Siemens Brothers. He remained there for seven years and then turned his attention to technical journalism. He was for a time assistant editor of the *Electrician* and afterwards of *Electrical Engineering* (of which he was part-proprietor) from 1906 until 1917, when publication ceased. Between the two World Wars he was a 'free lance' and occasionally contributed to *Nature* and other journals. He also did abstracting work for the Institution of Civil Engineers and the Institution of Electrical Engineers.

As befitted his Huguenot descent, he was a member of the Huguenot Society of London and became its honorary secretary in 1923, a post which he held until he was elected president in 1951.

In 1938 he joined the temporary part-time staff of the British Electrical and Allied Industries Research Association, and his services were placed at the disposal of the British Standards Institution to supervise the revision of the British Standard Glossary of Terms used in Electrical Engineering. In 1941 he joined the staff of the British Standards Institution, and when the revision of the glossary was completed he agreed to remain with the Institution to assist with the preparation of other glossaries and related work.

In his latter years Roget had no hobby other than his work at the British Standards Institution. After a full day at his desk or at a committee meeting, he would often work on at the hotel in which he lived, producing documents which a less enthusiastic person would have dictated next day at the office. In this way he kept up with the work of the thirty or so committees of the Institution of which he acted as secretary, in a way which amazed his colleagues and at a pace which would have done credit to a man of half his age. With his industry he combined a quiet sense of humour and a charm of manner which endeared him to all with whom he came into contact.

Understanding between individuals and between nations depends upon the correct use of language, and much of Roget's life was devoted to the means towards such understanding. Few people possess the patience, the wide knowledge, the love of words and the clarity of expression which are so essential to this task and which were possessed in such abundance by Roget.

He leaves a son and a daughter.

J. F. Stanley

We regret to announce the following deaths:

Sir Charles Arden-Close, K.B.E., C.B., C.M.G., F.R.S., formerly director-general of the Ordnance Survey, on December 19, aged eighty-seven.

Mr. J. G. Robb, recently deputy engineer-in-chief of Marconi's Wireless Telegraph Co., Ltd., on December 16, aged sixty-two.

Dr. W. C. Sillar, formerly lecturer in experimental pharmacology in the University of Edinburgh, on October 23, aged eighty-eight.

NEWS and VIEWS

Division of Biochemistry, Massachusetts Institute of Technology: Prof. J. M. Buchanan

A Division of Biochemistry in the Department of Biology has recently been started at the Massachusetts Institute of Technology, and Prof. John M. Buchanan, professor of physiological chemistry in the University of Pennsylvania, has been appointed the first professor and head of the Division as from July 1, 1953. The new Division will operate as an autonomous unit within the Biology Department, closely correlated with the other activities of the Department, particularly in the fields of general physiology and biophysics, and will be responsible for teaching and research in biochemistry at all levels—undergraduate, graduate and post-doctoral—in the Institute. All undergraduate students in the Biology Department will take at least one course in the Division of Biochemistry, and graduate degrees in biochemistry will be offered in connexion with the Division's research activities, which will mainly be concerned with the growth, structure and reproduction of cells. Housing for the Division will be provided on the sixth floor of the new John Thompson Dorrance Laboratories of Biology and Food Technology.

Prof. Buchanan graduated from De Pauw University, Greencastle, Ind., in 1939, and then took his M.Sc. at the University of Michigan and his Ph.D. at Harvard University. Except for two years at the Medical Nobel Institute, Stockholm, his subsequent career has been entirely at the University of Pennsylvania. He is widely known for his researches in the biosynthesis of biological compounds, particularly the purines and glycogen, and he has also made important contributions in the isolation and purification of enzymes. In 1951 Prof. Buchanan received the Eli Lilly Award in Biological Chemistry of the American Chemical Society.

Geological Society: Awards

The Council of the Geological Society announces the following awards for 1953: *Wollaston Medal:* Prof. Erik Stensiö, keeper of the Palæozoological Department in the Swedish Natural History Museum, Stockholm, for his fundamental researches on the lower vertebrates and for his remarkable techniques in palæontological research; *Murchison Medal:* Dr. F. Dixey, for his outstanding contributions to the geology of Africa and his distinguished services as director of the Colonial Geological Surveys; *Lyell Medal:* Dr. M. B. Bulman, for his important contributions to palæontology, particularly on the morphology of the Graptoloidea and to Lower Palæozoic stratigraphy; *Bigsby Medal:* Prof. K. C. Dunham, for his contributions to petrology and to the study of mineral deposits; *Wollaston Fund:* Mr. P. C. Sylvester-Bradley, for his researches on fossil Ostracoda and on Jurassic stratigraphy; *Murchison Fund:* Mr. C. D. Ovey, for his researches on fossil Foraminifera; a moiety of the *Lyell Fund* to Dr. Gilbert Wilson, for his works on structural geology, notably in Cornwall and the Highlands, and his studies of granitization and coastal geomorphology; another moiety of the *Lyell Fund* to Dr. D. A. Brown, for his contributions to the structural geology and palæontology of New Zealand, and particularly the Tertiary Polyzoa of that Dominion.

Institute of Metals: Awards

The Council of the Institute of Metals has made the following awards: *Institute of Metals* (*Platinum*) *Medal* for 1953 to Prof. Georg Masing, of the Institut für Allgemeine Metallkunde, University of Göttingen, in recognition of his outstanding contributions in the field of metallography; *Rosenhain Medal* for 1953 to Dr. C. E. Ransley, of the Research Laboratories, British Aluminium Co., Ltd., in recognition of his outstanding experimental and theoretical work on gas-metal equilibria.

Manchester College of Technology: Jubilee Brochure

In connexion with the jubilee of the Manchester College of Technology, an illustrated brochure has been issued (pp. 36; from the College) giving an excellent account of the origin of the College and its development since the opening of the present building in 1902. Up to 1918 the institution was known as the Municipal School of Technology; but it had already, in 1905, concluded arrangements with the Victoria University of Manchester for the institution, within the School of Technology, of the Faculty of Technology, which in its first session included 522 university students. In 1912 the School of Technology was for the first time listed with universities and university colleges in Great Britain which were in receipt of grants from the Board of Education. This was prior to the establishment of the University Grants Committee, and the Manchester Municipal School of Technology was the first municipal institution to be thus listed with university institutions. Although the brochure does not trace the earlier development to 1902 of the original Mechanics' Institute of 1824, it gives some indication of the research work carried out by the College, particularly during the two World Wars. Some account of the co-operation with industry which led first, during October 1917, to a course of lectures in scientific management and later, in 1926, to the establishment of the Department of Industrial Administration is included, and also of the post-war developments and the new buildings. Besides the thousand undergraduate university students for whom accommodation was planned for the three sessions

following 1946–47, the non-university registrations reached a peak of 8,558 in 1949, of whom 7,943 were part-time students, while in 1950 more than nine hundred students were attending post-advanced classes. According to a recent estimate, the extensions originally commenced in 1938 will almost double the present accommodation. Since 1924 the number of volumes and pamphlets in the library has increased from 12,000 to 33,500, and the number of periodicals taken from 130 to 420.

Technical Education in the North of England

A PAMPHLET entitled "Technical Education in the Northern Region", giving a summary list of courses which are available in the technical, commercial and art colleges and institutes of Cumberland, Durham, the North Riding of Yorkshire, Northumberland and Westmorland, has been issued by a sub-committee of the Northern Productivity Exhibition Planning Committee, organized by the Northern Regional Board for Industry in association with the Information Division of the Treasury and others. Since 1938–39 the number of full-time students in senior and advanced courses in the region has grown from 635 to 2,152, of part-time day students from 909 to 10,552 and of evening students from 19,714 to 26,836 (1950–51), though part-time day release remains below the average for Great Britain as a whole. The Exhibition itself, which was held in the City Baths Hall, Newcastle upon Tyne, during October 30–November 6, 1952, included a technical college exhibit.

German Hydrographic Institute, Hamburg : Report for 1951

THE German Hydrographic Institute's report for 1951, its sixth year of activity (pp. 72+12 pl. ; from the Institute, Hamburg 11 ; 1952), includes some retrospective statistics which go back to its foundation in 1946. On the whole, the Institute's work has been continued and progressively extended as in the years before, especially in the departments for nautical books and charts. Some events are mentioned which have a special importance for the Institute's further development. With regard to the work for the direct benefit of practical navigation, a committee has been established which includes representatives of all nautical and technical institutions, organizations and firms which are interested in the Institute's activities. This committee is to meet at suitable intervals in order to lodge requirements and make suggestions bearing upon the work of the Institute. As for the resumed participation in international scientific work, members of the Institute's staff took part in the meeting of the International Geophysical and Geodetic Union held in Brussels in August and September 1951, and in that of the International Council for the Exploration of the Sea held in Amsterdam in October 1951. Moreover, the Institute has been able to continue its research work in the North Sea from its vessel *Gauss*. In June 1951 a cruise was made in the Southern Bight of the North Sea for physical, chemical and plankton observations in association with contemporaneous British and Dutch fishery investigations, and a call was made at Lowestoft for discussions with British oceanographers there. During an autumn cruise in the German Bight and the Skagerrak, some methods and apparatus designed for practical marine seismology were tested, and several echograms of the deepest part of the Norwegian Trench were obtained. Following upon the Brussels and Amsterdam meetings referred to, the Institute was visited by many foreign scientific workers who had attended them.

Franklin's 'Philadelphia Experiment' on Lightning

THE May 1952 number of the *Journal of the Franklin Institute* (**253**, No. 5) is devoted to the subject of lightning protection in commemoration of the two hundredth anniversary of the 'Philadelphia experiment' (May 10, 1752) on the identity of laboratory and thunderstorm electrification which was proposed by Benjamin Franklin. It contains a reproduction of the first photograph of lightning, believed to have been taken by W. N. Jennings on September 2, 1882, and four articles, by B. F. J. Schonland, I. B. Cohen, K. B. McEachron and H. Norinder, respectively. The first two deal with the historical background. Prof. Schonland gives an account of the experiments and hypotheses which led Franklin to propose the famous experiment and the lightning rod as a protective device, and Prof. Cohen describes the considerable prejudice which was aroused against the introduction of lightning rods. He quotes Prof. Schonland's conclusion from his recent book that "lightning still takes a considerable toll of unprotected property in the country from which the rod came", and points out that, although lightning was given the sixth place in importance among the causes of fire during 1921 by the United States National Board of Fire Underwriters, the number of buildings with adequate lightning protection is still but a small fraction of those that require rods. Dr. McEachron, of the General Electric Co., discusses lightning protection since Franklin's day, in particular with respect to communication systems, transportation and the electrical industry. Finally, Dr. Norrinder, of the Institutet för Högspanningsforskning, University of Uppsala, deals with experimental research into lightning discharges and effects in their vicinity. Meteorological aspects and the long-distance effects—atmospherics—are not considered. Optical methods, photographic methods and high-speed cathode-ray oscillograph methods of recording lightning discharges are described, and some of the results obtained, revealing the leader stroke mechanism, are discussed and illustrated.

Handbook of the New Zealand Department of Scientific and Industrial Research

THE Department of Scientific and Industrial Research, New Zealand, has issued an illustrated and well-produced Departmental Handbook (pp. 68. Wellington : Govt. Printer, 1952) collecting much information previously only available from separate sources. An organization chart and brief account of the organization and administration of the Department is supplemented by some historical notes on its development and by maps indicating the geographical location of the units. The bulk of the Handbook consists of brief accounts of the functions and organization of the several divisions, laboratories, sections, etc., and of the incorporated research associations, including lists of staff. There is also a list of committees and their membership and of organizations in receipt of grants from the Department. The Handbook is completed with an index.

New Light on Gnetales and Ephedrales

PROF. A. J. EAMES has considered in some detail, and in the light of modern knowledge, the relationships of that much-discussed plant group, the

Gnetales—comprising *Gnetum*, *Welwitschia* and *Ephedra* (*Phytomorph.*, 2, 1, 79; 1952). These plants have long been prominent because of their very curious morphology and diverse habit, and because they appear to occupy a position intermediate between gymnosperms and angiosperms. The evidence now available points to the need for an extensive taxonomic revision. As a result, the three families are separated and raised to ordinate rank. Moreover, it is recognized that the Ephedrales have no phylogenetic relationship to the Welwitschiales and Gnetales. They are, however, closely related to the Cordaitales, both having similar appendicular ovules. *Ephedra*, in fact, is regarded as a derivative of ancient cordaite-conifer stock.

Papers from the Arcetri Astrophysical Observatory

PUBLICATION No. 67 of the Faculty of Mathematical, Physical and Natural Sciences of the University of Florence, entitled "Osservazioni e Memorie dell' Osservatorio Astrofisico di Arcetri" (pp. 141, 1952), consists of eleven papers contributed by seven authors. These papers deal with a variety of subjects: correlation coefficients between areas of sunspots and areas of calcium and bright $H\alpha$-flocculi; results of the examination of the mean heliographic latitude of sunspots and that of bright flocculi, from which it appears that the former are smaller than the latter; relative photometric intensities of chromospheric flares, measured monochromatically in $H\alpha$ and $K2{\cdot}3$ lines, on 258 spectroheliograms recorded during 1950 with the solar tower of Arcetri Observatory; study of the eleven-year cycle of solar prominences, without taking into consideration the distinction between those in high and low latitudes, and comparing prominences with filaments, some differences in their behaviour being detected; photometric measurements of the ghosts given by the grating of the Arcetri solar tower; relative intensities of flares and bright flocculi observed in $H\alpha$ light on spectroheliograms taken at Meudon, and a comparison with those taken at Arcetri, etc.

The Night Sky in January

FULL moon occurs on Jan. 0d. 05h. 05m., U.T., and also on Jan. 29d. 23h. 44m., and new moon on Jan. 15d. 14h. 08m. The following conjunctions with the moon take place: Jan. 9d. 09h., Saturn 8° N.; Jan. 19d. 01h., Mars 4° S.; Jan. 19d. 01h., Venus 4° S.; Jan. 23d. 02h., Jupiter 7° S. In addition to these conjunctions with the moon, Venus is in conjunction with Mars on Jan. 18d. 02h., Venus being 0·2° N. Mercury, a morning star, rises at 6h. 50m. on January 1, but later in the month it draws too close to the sun for favourable observation. Venus, an evening star, sets at 19h. 50m., 20h. 30m. and 21h. 10m. on January 1, 15 and 31, respectively, stellar magnitude averaging $-3{\cdot}9$ and the visible portion of the illuminated disk varying between 0·65 and 0·52. Mars is an evening star, setting about 20h. 35m. throughout the month; its stellar magnitude varies between 1·2 and 1·3. Jupiter sets at 3h. 10m., 2h. 10m. and 1h. 15m. at the beginning, middle and end of the month, respectively, its stellar magnitude averaging $-2{\cdot}1$. Saturn, a morning star, rises at 1h. 40m., 0h. 45m. and 23h. 45m. on January 1, 15 and 31, respectively; its stellar magnitude is about 0·9, and it lies a little north-east of α Virginis (Spica). There is only one occultation of stars brighter than magnitude 6 in January, namely, π Canc., which reappears at 6h. 18·3m., assuming that observations are made at Greenwich. A total eclipse of the moon takes place on January 29/30 and is visible in the British Isles. The circumstances of the eclipse are as follows:

Moon enters penumbra	Jan. 29d.	20h.	40·1m.
Moon enters umbra	29	21	54·1
Total eclipse begins	29	23	04·6
Middle of eclipse	29	23	47·3
Total eclipse ends	30	00	29·9
Moon leaves umbra	30	01	40·4
Moon leaves penumbra	30	01	54·5

The earth is at perihelion on January 2.

Announcements

PROF. J. F. BAKER, professor of mechanical sciences and head of the Department of Engineering, University of Cambridge, has been awarded the Ewing Gold Medal of the Institution of Civil Engineers, in recognition of his contributions to engineering research.

IN reply to a question in the House of Commons, the Minister of Works stated that the planning of the Government Science Centre has had to be deferred in view of the need for economy. When the economic situation improves, it is hoped to lease a site on the South Bank immediately below Waterloo Bridge.

THE annual exhibition of the Television Society, dealing with television engineering or production or with the production of television programmes, will be held during January 23–24, 1953, at 155 Charing Cross Road, London, W.C.2, by invitation of the Edison Swan Electric Co., Ltd. The exhibition will be open as follows: January 23, 6–9.30 p.m., members and friends; January 24, 10.30 a.m.–6 p.m., members. Public admission is by invitation card, obtainable from members of the Society, patron members or from the lecture secretary, G. T. Clack, 43 Mandeville House, Worsopp Drive, London, S.W.4.

A symposium on anticholinesterases, arranged jointly by the British Pharmacological Society and the Fine Chemicals Group of the Society of Chemical Industry, will be held during March 27–28, 1953, at the Wellcome Research Institution, Euston Road, London, N.W.1. The symposium will be in four sections: chemical features which confer inhibition; mode of action *in vitro*; mode of action *in vivo* (acute effects); mode of action *in vivo* (chronic effects). Further information can be obtained from the honorary secretary of the British Pharmacological Society, Mr. George Brownlee, at the Physiology Department, King's College, Strand, London, W.C.2.

AN International Congress on Electroacoustics will be held in the Netherlands during June 16–24, 1953, under the auspices of the International Commission on Acoustics of the International Union of Pure and Applied Physics. Lectures and invited short contributions will be read covering the following sections: (1) sound recording, (2) public-address systems, (3) acoustic measurements, (4) hearing-aids and audiometers, (5) electroacoustics in ultrasonics, and (6) electroacoustics applied to musical instruments. These will be followed by a symposium on the sound insulation of lightweight structures. Further details can be obtained from the secretary, Dr. P. A. de Lange, Mijnbouwplein 11, Delft.

THE lectures delivered at the vacation school on the "Insulation of Electrical Equipment" held at the Imperial College, London, in September (see *Nature*, Dec. 13, p. 1006) are being published in book form by Chapman and Hall, Ltd., 37 Essex Street, London, W.C.2, under the editorship of Prof. Willis Jackson.

UNIVERSITY COLLEGE, IBADAN

FORMAL OPENING

ON November 17, Marshal of the Royal Air Force Lord Tedder, Chancellor of the University of Cambridge, formally opened the buildings of what in a few years time will be the University of Nigeria. This was the fourth anniversary of the ceremony when the then Secretary of State for the Colonies, Mr. Arthur Creech Jones, cut the first sod and inaugurated the building programme; the Soil Science Laboratory of the Department of Agriculture appropriately stands on the spot. Less than six years ago a commission appointed by the Inter-University Council for Higher Education in the Colonies, under the chairmanship of Sir William Hamilton Fyfe, selected the site, which was then a tract of unsurveyed and almost impenetrable bush.

The capital cost of the new buildings has been provided by a grant from the British Exchequer under the Colonial Development and Welfare Act. The sum of £1,500,000 was set aside in 1947, and on November 17 Sir Christopher Cox, educational adviser at the Colonial Office, announced, on behalf of the Secretary of State, that a further £200,000 had been added, to offset increased prices and to allow the whole of the first phase of the scheme to be completed. The whole of the recurrent costs of the College, which now amount to about £400,000 per annum, come from Nigerian sources, either as a direct subvention from the Government or as interest from endowments from the same source or from the marketing boards (for example, the Cocoa Marketing Board has endowed the School of Agriculture to the extent of £1,000,000).

The site of nearly 3,000 acres was acquired for the College by the Nigerian Government and lies some three miles north of Ibadan. Ibadan is the largest town in tropical Africa, with an estimated population of half a million inhabitants, mostly Yoruba, but with substantial numbers of settlers from other parts of Nigeria, and a few hundred European, Syrian, Indian and other expatriates.

The site, as well as containing the main academic buildings, houses more than a hundred members of the academic staff, and several hundred junior employees. The greater part of the 3,000 acres will, however, be developed as experimental farms by the Department of Agriculture.

The buildings, designed by Mr. Maxwell Fry and Miss Jane Drew, comprise residential accommodation for nearly six hundred student in halls of residence and teaching blocks for the departments in the Faculty of Arts, including a theatre, library, administration building and an assembly hall; this last is a gift from the United Africa Company, and is to be called Trenchard Hall, after Lord Trenchard, chairman of the Company, who during 1903–10 saw service with the Army in Nigeria.

There are at this stage four halls of residence, in each of which the plan follows the general recommendations of the committee set up by the vice-chancellors and principals of universities in Britain. Each undergraduate has a separate study-bedroom, and there are a communal dining hall and recreation rooms in each hall of about 150 students. The buildings have been planned for tropical conditions, and although they are built around courtyards, most of the residential blocks run east and west to avoid direct sun shining into the rooms. Each room has through ventilation, and each study-bedroom a private veranda.

The laboratories, for the Departments of Chemistry, Physics, Botany and Zoology in the Faculty of Science, for Agriculture, for Anatomy, Physiology and Pharmacology in the Faculty of Medicine, have been planned for construction with the maximum economy, and so as to be easily adapted and converted to meet changing needs. These buildings have been designed by Mr. J. Hoskins, of the College staff, collaborating where necessary with the architects to ensure that the façade conforms with the general layout plan. These laboratories are of one story only (this is much cheaper to construct under Nigerian conditions than loftier buildings), and they are planned to be able to house a much larger number of students and of staff than will immediately be necessary. Thus the Departments both of Chemistry and of Physics have each about 18,000 sq. ft. of laboratory space.

The buildings now constructed are intended to house the College in the first phase of its development; but the site has been planned so that a great expansion is possible. More halls of residence are likely to be the first necessity, and sites for at least six more are scheduled. The teaching departments can be easily extended to take several thousand students,

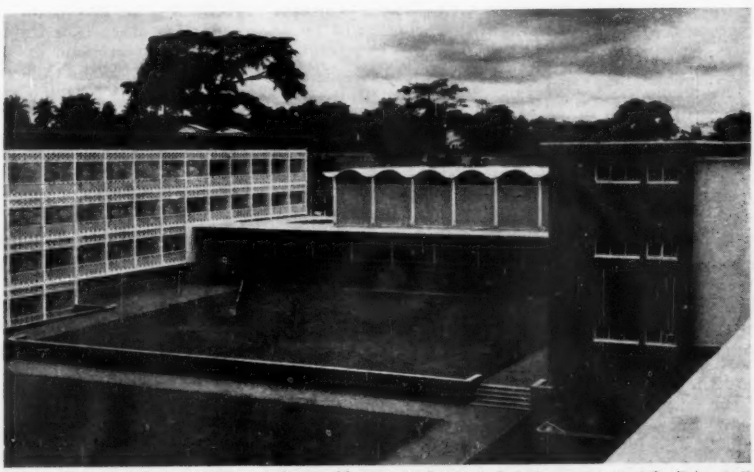

Fig. 1. Part of the court inside a hall of residence; students' study-bedrooms on the left, dining hall centre

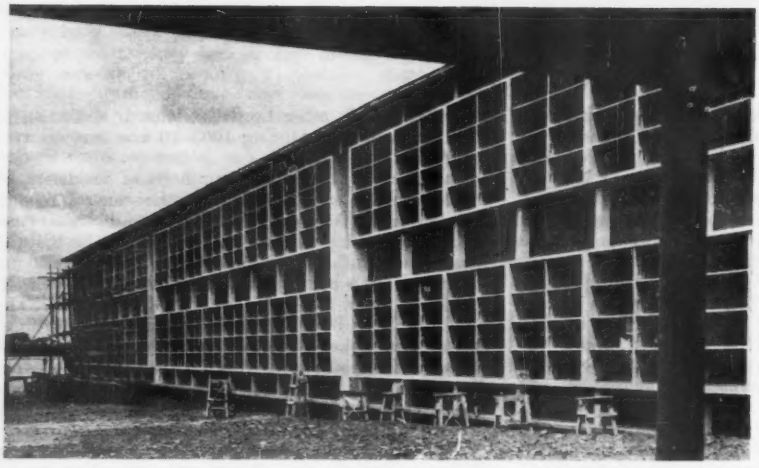

Fig. 2. North wing of the arts building, containing Departments of Geography, Mathematics and Phonetics

though those at present responsible for planning the College think that when the undergraduate community reaches about 2,500 a start should be made with a second Nigerian university in another part of the territory.

The College has already been working for more than four years in temporary buildings in a converted military hospital. The preclinical and agricultural students have now moved into their permanent quarters; but the Faculties of Arts and Science will not be able to move for some months. There are at present in residence in Ibadan nearly 400 undergraduates, and an academic staff of more than a hundred.

Ibadan students work for degrees of the University of London. The College is in a "special relationship" with the University; this means that, while academic standards are guaranteed, there is some latitude in adapting the syllabus to meet local needs. Thus in the biological sciences, geography and history, for example, special courses have been evolved. The preparation of these syllabuses, which will develop as the appropriate research work into African problems progresses, gives useful experience which will be of value when the College becomes an independent university.

The whole course leading to general or honours degrees in a wide range of arts and science subjects, and in agriculture, can be completed in Ibadan. In medicine, teaching at present only extends to the end of the preclinical course; for clinical studies, students proceed overseas, but work is proceeding on the Teaching Hospital (for which the Nigerian Government has granted £2,250,000) and soon it is hoped that the final London M.B., B.S., may be taken in Ibadan. At present there are no hospitals in Nigeria suitable to obtain recognition for teaching of the appropriate standards.

Nigeria, with a population estimated at not far short of 30,000,000, will require far more graduates than the College can at present produce, but the size of the entry is at the moment largely dependent on the production of suitable freshmen by the secondary schools. So far, few suitable candidates have failed to secure entry. An attempt is being made to maintain a proper balance of the different faculties, and notwithstanding the obvious demand for well-qualified scientists and technicians, arts subjects are by no means neglected.

Academic work in the tropics often suffers from the lack of library facilities. The library at Ibadan already contains more than 70,000 volumes, and receives about a thousand current periodicals. The new building will take, without extension, more than a quarter of a million volumes. Microfilms are extensively used, being frequently flown out from Europe for the urgent use of readers, and the library can make its own microfilms and photostat copies for the use of readers elsewhere. Many back-numbers of otherwise unobtainable scientific journals are available on microcards; Ibadan was the first Commonwealth library to use this technique.

Everyone at Ibadan realizes that the future standing of the University College will depend on the quality of the original work carried out there, both by the staff and by visiting investigators using the College's facilities. All departments are planned not only to allow for an increase in student numbers, but also to accommodate visitors from overseas. Several such workers have spent considerable periods at Ibadan. Fulbright Scholars from the United States have, for example, studied primate physiology, poultry husbandry, indigenous songs and other cultural problems. A Medical Research Council team investigated vegetable precursors of cortisone. But the main research must always be done by the College itself, and a good start has been made in all faculties; in medicine, where no clinical teaching will take place for a few years, research will largely determine the details of the courses which will eventually be given.

At this stage it is impossible to foretell the exact future development of the College. This depends only in part on the College itself. The political situation in Nigeria is changing rapidly, and it is the more

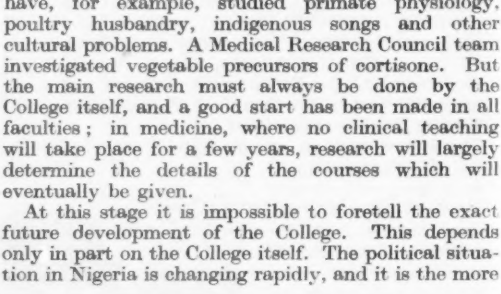

Fig. 3. Elementary chemistry laboratory; the Department of Chemistry includes three similar parallel buildings

moderate politicians who speak of "Dominion status in 1956". The College is a fully autonomous institution, and so far there have been few attempts, save by the less responsible organs of the popular press, to interfere with this autonomy. Nevertheless, until the College and its standards are firmly established the danger of outside political pressure will remain, and will impose an added strain on those responsible for the well-being of an institution on which the future of Nigeria itself depends so greatly.

INTERNATIONAL FEDERATION FOR DOCUMENTATION

CONFERENCE IN COPENHAGEN

THE International Federation for Documentation held one of its 'restricted' conferences in Copenhagen during September 28–October 4, which was attended by representatives of some sixteen countries. These conferences consist of a number of meetings of the council and of the active specialist committees of the Federation. Among the committees which met on this occasion were those on universal classification, mechanical selection, technical means of documentation, abstracting, training, and information services. Meetings were also held between members of the staff of the United Nations Educational, Scientific and Cultural Organization and representatives of the council of the International Federation for Documentation, the International Federation of Library Associations and other international bodies concerned with documentation, archives and librarianship. As a step towards closer collaboration, it was agreed that both the International Federation for Documentation and the International Federation of Library Associations should become members of the other's organization and that the next conferences of the two bodies should take place simultaneously in Vienna in 1953. It was also agreed with the representatives of Unesco that a joint consultation committee of international non-governmental organizations in the field of librarianship, documentation and archives be established, and that this committee should arrange the next world conference on these subjects to be held in 1954 or 1955.

One of the main items discussed by the council of the Federation was the report of its committee on reorganization, which was set up at the end of the conference held in Rome in 1951. This report, which was accepted after minor modification, restated the aims of the Federation in terms suitable for the present; in particular, it made clear that such a body should restrict its activities to those which are truly international in character, leaving studies of a more general nature to its national constituent bodies. Similarly, it was agreed that international technical studies should not necessarily be carried out by the general secretariat but allocated to appropriate national members who would undertake them for the benefit of the Federation as a whole. It also recommended that international specialist bodies should be accepted as members of the Federation in addition to the national co-operating bodies (Aslib in the case of Great Britain). It was recognized that, with the increased amount of research undertaken, especially in the pure and applied sciences, and the consequent volume of publication, special problems of documentation are arising in many scientific and technical fields. As a result, a number of specialist international bodies have already been established, such as the International Council on Building Documentation which was meeting at Copenhagen at the same time as the International Federation for Documentation. The Federation felt itself to be in a position to give advice to international bodies for specialized topics, such as the various international scientific unions, on documentary aspects of their work, and decided to create facilities for such bodies to join the Federation and participate fully in its work.

Among the technical matters agreed as appropriate to the programme of the Federation for 1953, priority was given to the proposals for a guide to centres for microfilm and photocopying services, and centres for international loans and translation services; the production of manuals for instruction in documentation; a directory of the effective members of the Federation, with a description of their activities; a study of auxiliary publications, including 'unpublished' reports of scientific work; a study of costing and economics in the preparation and sale of photocopies; and a manual of documentary reproduction.

This conference, with its wide scope of technical interest, demonstrated clearly the need for improved services of documentation and information as well as the interest of scientific and technological workers in problems resulting from the mounting pressure of publication. Although a number of international organizations are operative in this and neighbouring fields, the International Federation of Documentation, in encouraging co-operation with other bodies while at the same time improving its own organization and procedures, is showing real leadership and finding a useful continuing function.

ADVISORY COMMITTEE ON ARID ZONE RESEARCH

MEETING IN LONDON

THE Advisory Committee on Arid Zone Research set up by the United Nations Educational, Scientific and Cultural Organization held its fourth meeting in the Royal Society's rooms, Burlington House, London, during September 29–October 1. Following its former policy, the Committee's recommendations were concerned to a large extent with the dissemination and exchange of information by means of reports and symposia. Reports have already been obtained and circulated on arid zone hydrology, on plant ecology, on the climatic history of arid regions and on the utilization of salt water. A successful symposium on arid zone hydrology organized jointly by Unesco and the Turkish Government was held in Ankara last April. The Committee recommended that qualified experts be commissioned to prepare reports reviewing research on energy sources, including wind and solar energy and their utilization in arid and semi-arid regions, and also on the general characteristics of arid zone soils and their modification. It also recommended that a survey of current research in the field of arid zone plant ecology be prepared. The symposium planned to be held in 1953 will deal with this field of plant ecology in arid regions, and the Committee considered its programme and plans

for holding it in a Latin-American country in the autumn.

Plans were also discussed for the production of a handbook to assist those confronted with the task of collecting basic data required before schemes can be prepared to develop an arid or semi-arid area. Such a handbook would aim at serving two purposes. It would first direct the attention of persons concerned with organizing development to the various and interrelated fields in which data are needed before satisfactory plans for such development can be made. Secondly, it should give information as to the best methods of collecting and presenting basic data in a form that supplies the information needed for their practical application.

A scheme is now in operation in which certain institutions carrying out research relating to arid zone problems may be designated as suitable for the exchange of personnel and information and for the reception of visiting scientific workers. A number of applications for designation under this scheme were considered by the Committee, which recommended that the following institutions be added to those already designated at earlier meetings :

Commonwealth Research Station (Murray Irrigation Areas), Merbein, Victoria.
Division of Plant Industry (C.S.I.R.O.), Black Mountain, Canberra.
Irrigation Research Station (C.S.I.R.O.), Private Mail Bag, Griffith 58, New South Wales.
Katherine Research Station, Katherine, Northern Territory.
National Field Station, "Gilruth Plains", Cunnamulla, Queensland.
Information on Regional Pastoral Laboratory, Denilquim, Box 26, P.O., New South Wales.
Laboratorium voor Grondmechanica, Oostplantsoen 25, Delft.
Waterloopkundig Laboratorium (Hydraulic Laboratory), Raam 61, Delft.
Amarillo Conservation Experiment Station, Box 2169, Amarillo, Texas.
Department of Geology, University of Southern California, 3518 University Avenue, Los Angeles 7, California.
Inter-Mountain Forest and Range Experiment Station, U.S. Forest Service Building, Ogden, Utah.
Information on Reclamation Engineering Centre, Denver, Colorado.
South-western Forest and Range Experiment Station, Tucson, Arizona.
University of Arizona, Tucson, Arizona.
University of California Citrus Experiment Station, Riverside, California.

Particulars of these institutions and of the facilities available at each can be obtained from Unesco (19 Avenue Kléber, Paris 16e). The Committee also recommended that member States be reminded of this scheme and be supplied with a full list of institutions at present associated under it.

As a result of an earlier recommendation by the Committee, a survey has been conducted by Unesco of institutions engaged in research on arid zone problems, and the Committee recommended that the information thus collected should be made use of to compile a directory of institutions engaged in arid zone research.

On the research side the Committee recommended that assistance be given to the following projects. (1) A project proposed by the Institut Français d'Afrique Noire to study the effects on plant cover of natural factors, mainly climatic, and of human intervention such as grazing, trampling and wood cutting. Data on this subject are much needed, especially since they bear on the deterioration of natural pastures. (2) A project proposed by Dr. F. W. Went, of the Earhart Plant Research Laboratory, California Institute of Technology, to study the role of dew in plant growth in arid regions. (3) A project proposed by Dr. K. Smidt Nielsen, of Duke University, North Carolina, to study the physiology of the camel and of other desert mammals. This work would extend that already carried out by Dr. and Mrs. Smidt Nielsen on the physiological mechanisms which enable certain desert rodents to live on dry food without drinking water. (4) A project proposed by Prof. L. Picard, Geological Institute, Jerusalem, Israel, to investigate the climatic changes that have taken place during the Quaternary in the arid and semi-arid region of the south-east Mediterranean, initially by means of a study of the peat deposits of northern Galilee.

EUROPEAN COUNCIL FOR NUCLEAR RESEARCH

SESSION IN AMSTERDAM

THE third session of the European Council for Nuclear Research was presided over by Prof. P. Scherrer when it met at the Academy of Sciences, Amsterdam, during October 4–6. The main work before the Council was to consider the offers which had been made by various member States for the site of the proposed laboratory, to hear reports of progress made by its four study groups, and to consider a report from its secretary-general, Prof. E. Amaldi, on the organization and financial implications of future European co-operation in nuclear research. Last June the Council sponsored a scientific conference at Copenhagen to promote a broad exchange of views upon the problems of nuclear research which could be most profitably dealt with by international co-operation. As a result of this conference, it has been decided that the study of mesons and the other new particles which have recently been found in the cosmic rays should be developed by international co-operation, and by the construction of high-energy machines in a suitable centre so that these particles might be created artificially. Four working-groups were formed by the Council to carry out the following respective tasks : the first to design a 600-MeV. synchrocyclotron ; the second to design a proton synchrotron of not less than 10 GeV. (10^{10} eV.) energy ; the third to study theoretical and experimental developments having a bearing on the aims of the Council and to promote other forms of European co-operation in nuclear physics ; and the fourth to explore the organization and structure of a suitable laboratory.

Rapid progress with the design study of the 600-MeV. synchrocyclotron was reported by Prof. C. J. Bakker. The main features of the magnet design have been settled, and also the layout of the vacuum chamber and radio-frequency system. At one stage it had been intended to use a rotary condenser to provide the necessary radio-frequency tuning, but as a result of a recent visit to the Radiation Laboratory of the University of California, the use of a vibrating-reed method of tuning is now being studied. The general design has advanced to the stage where it is necessary to start considering the manufacture of the various components.

Prof. O. Dahl reported that, since the last Council meeting in Copenhagen in June, an event of considerable scientific interest has occurred which has profoundly affected the work of the Proton Synchrotron Group. Drs. E. D. Courant, M. S. Livingston and H. S. Snyder, of the Brookhaven National Laboratory, have proposed a new focusing principle applicable to a high-energy proton synchrotron.

This principle splits the magnetic guiding field into sectors that are alternately strongly focusing and defocusing. The net effect of a combination of sectors in this way is a strongly focusing action such that any oscillations about the equilibrium orbit induced in the motions of the particles are kept small in amplitude. This is of outstanding importance since, for a given energy, the particles may be constrained within an annulus of much smaller dimensions than is the case with a machine of conventional design. Preliminary study has suggested that it should be quite practical to design a machine for 30 GeV. in which the energy to be stored in the magnetic field is not more than that required for the present 3-GeV. machine at Brookhaven. The work of the Proton Synchrotron Group has been changed to take advantage of this new idea. The Council expressed its approval of this.

One part of the work of the Council's Group directed by Prof. Niels Bohr is to promote forms of European co-operation in nuclear physics other than the creation of the laboratory. Sweden has offered to the Council facilities on the 200-MeV. cyclotron which is now working at the University of Uppsala, and Prof. Bohr reported that he has arranged on the Council's behalf for two or three young nuclear physicists from other European countries to take part in work with the machine. Great Britain also has offered facilities on the 400-MeV. cyclotron now nearing completion at the University of Liverpool, and this, too, has been accepted. Prof. Bohr also described an experiment carried out at the Institute of Theoretical Physics, Copenhagen, by Prof. J. C. Jakobsen, which was of interest to the Council because it illustrated the new focusing principle proposed for proton synchrotrons. Four sections of a magnet were used, being constructed so as to provide focusing and defocusing fields in alternate sections. Particles were injected from an alpha-particle source into these fields, and it has been shown by the use of a photographic plate that they were brought to a focus at the end of the fourth section. This experiment has provided confirmation of the first-order theory of the new focusing method. While it was recognized that the experiment still left unanswered important questions about particle stability under practical operating conditions, the Council expressed its appreciation of the work.

In a report by Dr. I. L. Kowarski, it was stated that the main work of the Laboratory Group since the Council's last meeting has been concerned with obtaining the relevant technical information about the sites offered for the laboratory and with the preparation of a draft convention for the building stage. Four member States had made formal applications to the Council to have the laboratory built in their territory, namely, France, Denmark, Holland and Switzerland; each country had supplied detailed information about its site and had been invited to make the case for it to the Council. From the information given, it appeared that any of the four sites would be satisfactory on purely technical grounds. It was generally recognized that the choice would also take into account other considerations, such as the balance between international common good, plus the national benefit from it, on one side, and the necessary sacrifice of national resources, on the other. Competition between each of the four member States to have the laboratory within its territory was keen, but the subject was debated in a courteous atmosphere, and when all but Switzerland had withdrawn their offers, however reluctantly Geneva was unanimously chosen as the site for the future laboratories.

Since the Council had decided at its second meeting to give support to cosmic-ray research, the secretary-general reported to it the results of an international expedition which had been independently organized and operated in the Mediterranean area to carry out research in the high atmosphere using balloons. A total of thirteen balloons has been launched, and 1,300 c.c. of emulsion exposed to radiation at 70,000 ft. for an average time of 6½ hours has been recovered. This is approximately ten times more emulsion than has previously been exposed. It was considered that, besides providing a considerable amount of material for research work, the expedition has been very useful for improving the technique of balloon launching.

In his draft of an interim report for the governments of member States, the secretary-general outlined how the Council came into being, its present stage of development and its plans for the future. At the present time studies concerning the equipment and organization of a laboratory are in full progress. It is hoped that by the spring of 1953 these studies will have advanced sufficiently to allow member States to take final decisions regarding the construction of an international nuclear research laboratory, and the organization of other forms of co-operation in nuclear research. It is estimated that the next stage of development will last seven years and cost a total of 27 million dollars, after which the estimated annual running cost of the laboratory would be a maximum of 1½ million dollars. Very preliminary consideration was given to questions of organization which will arise in the third stage and to the form of the convention which will set out the constitution of the organization. This report is to be studied again by the Council before it is submitted to the governments.

TERCENTENARY OF THE LEOPOLDINA ACADEMY, SCHWEINFURT

THE tercentenary of the foundation of the Leopoldina Academy in Schweinfurt, Bavaria, in the West Zone of Germany, was commemorated during July 13–15 under the auspices of the civic authorities and Historical Society of the town. This was in the nature of a *Nachfeier* to the main celebrations at Halle in the East Zone of Germany (see *Nature*, April 5, p. 576), at which the Schweinfurt delegate was Dr. Josef Helfrich. Prior to the zonal split, the late president of the Academy, Prof. Emil Abderhalden, who died in Zurich in 1950, had hoped for the tercentenary celebration to be held in Schweinfurt.

The Senate of the Academy at Halle, under its newly elected president, Prof. Otto Schlüter, and new senior vice-president, Prof. Heinrich Brandt, was represented by the secretary, Prof. Rudolph Zaunick, of Dresden (East Zone), who placed a wreath on the grave of the founder, Dr. Johann Lorenz Bausch (1605–65), reported on the present activity and projects of the Academy, and held a business meeting of members. The Martin–Luther University of Halle was represented by the rector, Prof. Rudolf Agricola. Prof. Michele Gortani brought greetings

from the University and Academy of Bologna. A telegram was read from the veteran member, (the late) Sven Hedin, the Swedish explorer.

Prof. Zaunick spoke at the opening session on "Idee, Form und Inhalt der Akademie in der Antike". He showed how the modern idea of a scientific academy goes back not to the Ακαδημεια of Plato, which excluded and explicitly ridiculed experimentation, but to Ptolemy's Μουσειον.

At the scientific session, Prof. Wilhelm Lorey, of Frankfurt, spoke on "Persönliche Erinnerungen an Mathematiker unter den einstigen Akademie-Mitglieder". The Leopoldina Academy, which started as a medical society, took in no pure mathematicians as such until 1876. But some members, such as Werneburg, Goethe's contemporary, like him hostile to Newton's colour theory, and a fanatical protagonist of the duodecimal system, had started life as mathematicians, and many more, like Goethe, recognized the great educative value of mathematics. A pupil of Georg Cantor at Halle and of Felix Klein at Göttingen, Prof. Lorey recalled that he was often the sole audience at Cantor's lectures; and as one of the very few surviving contemporaries of Grace Chisholm (afterwards Mrs. W. H. Young) at Klein's seminar, he told the story behind her 'unforgettable' first appearance in the famous armchair at Klein's house. An enlightened Prussian Minister for Education, who thought mathematics the best subject to use as a guinea pig in testing whether women could or should be admitted to the universities, but wished to create no precedent for German women, entrusted to Klein the task of making suitable inquiries on his professional travels abroad. Grace Chisholm came from Cambridge and Mary Winston from the United States, and by their success opened up university careers to German women. The talk was illustrated by lantern-slide portraits of many eminent mathematicians whom the speaker had known personally.

Dr. Steck, of Nuremberg, under the title "Albrecht Dürer als Mathematiker und Kunsthistoriker", claimed that Dürer had made a thorough study of mathematics and expressed life-long ideas on the unity of beauty and truth in his last three written works, "Unterweisung der Messung . . ." (1525), "Befestigungslehre" (1527) and "Proportionslehre", published posthumously (1528).

Prof. Hans Gallwitz, director of the Geological Institute at Halle, gave a talk of the greatest interest on "Ausgrabungen von Wirbeltieren und Insekten in der Eozänen Braunkohle". Unique palæontological discoveries have been made in the open-cast coal-mines in the Geiselthal near Halle. Excavations started by J. Weigelt in 1928 have only since the Second World War been successfully resumed, and praise is due to the mine-management and workers for their consistent co-operation. A film taken on the spot showed how specimens are detached and treated for preservation. The finds are unusually complete: not only whole skeletons, but also some skin, muscle and other soft-tissue remains are found, and even colours have been preserved in some green plant leaves and iridescent beetles. It is clear that the rate of sedimentation was rapid enough to prevent the attack of organic substances by atmospheric oxygen. Moreover, large desert tracts surrounded the district, isolating it and its inhabitants. The coal strata have an extensive surface area and attain a thickness of up to 100 m. on the southern rim. Tectonic movements, and particularly subsidence due to salt-leaching in the underlying Permian, can be clearly traced in the profiles; the formation of deep water-holes produced by the aforementioned process was particularly favourable to the concentration of specimens; others are found closely scattered over certain areas, called *Leichenfelder*, which were subject to recurrent flooding and which must have been formed as the result of periodically recurrent catastrophes.

The period, about forty million years ago, to which the finds belong lies near the beginning of the mass-development of the mammalian order. Plant remains clearly indicate a tropical and sub-tropical climate, and a dual rainy season is evidenced both by the two-fold lamination in the coal profile and by the otoliths of fish. In fishes and frogs, the shape of cutaneous pigment-carriers as seen under the microscope points to asphyxiation. Minute specimens of insect larvæ, pollen grains of the order of 10^{-6} gm. in weight, and even bacteria in the tracheæ of insects have been discovered. Among the finds are giant serpents, long-legged alligators, crocodiles with partially incubated eggs, a mammal transitional between insectivores and prosimians (with both hairs and spines), and one of the early prototypes of the horse, one foot high, with three toes on the hind-feet and four on the fore-feet.

Prof. H. Burgeff, of Würzburg, fresh from a visit to the United States, spoke on "Samenkeimung, Entwicklung und Kultur deutscher Orchideen", elucidating by diagrams and lantern-slides his method of cultivation in a double flower-pot, the seeds being planted individually in a net or weft of fungus-threads. The method has succeeded for all indigenous orchids, after guarding against the danger of destruction by mice, whereas the usual method has always failed except for the Platanthera.

Several speakers, notably Prof. Hämel, of the two-hundred year old Bavarian Academy of Sciences, Prof. D. Ackermann, of Würzburg, and Dr. F. Gademann, of Schweinfurt, did justice to the life-history and supra-national aims of the Leopoldina and of its foundation members—Brausch, Fehr, Metzger and Wohlfarth. These last-named were the first to put into practice the precepts, set out in the "New Atlantis" by Francis Bacon, for a scientific academy such as every principal city of Europe was soon to possess (London 1662, Paris 1666, Berlin 1711, Madrid 1713, St. Petersburg 1725, etc.). It is remarkable that this occurred in a small market-town, with a strong industrial background, in times of disruption rather like our own. A quotation that mystified some of the audience was from the curious charter that Kaiser Leopold I granted the Academy in 1687, when also it acquired its full name, conferring, as one of the normal privileges due to the Court rank bestowed on the president by the charter, the right to "legitimize illegitimate children" and to "declare dishonourable persons honourable".

Schweinfurt has preserved intact the fine library of more than a thousand volumes left to it by Dr. Bausch, chiefly on medical and botanical subjects; a large part was on view, together with works by other local Academy members—notably that on Japan by Philipp Franz von Siebold (1832), and with it his "Life" by the Japanese, Prof. Shuzo Kuro (Tokyo, 1926), the largest biography of a European ever written by an Asiatic.

An impersonation of the native poet Friedrich Rückert (1788–1866), a Haydn serenade in the courtyard of Mainberg Castle and a visit to the exhibition of medieval Franconian church art at

Würzburg Castle—the most striking feature of which was a large collection of the sculptures of Tilman Riemenschneider (1460–1531)—were the main social items in the proceedings, which were essentially informal. As in the case of the Halle celebrations, detailed reports will be published in the *Nova Acta Leopoldina*, including a full account of Prof. Gallwitz's researches. But, as yet, no copies of the current year's issue have reached the British bodies who were recipients before the War (and whose publications have been received up to date by the Academy), although at the time of the Halle meeting it was hoped to make up the deficiency forthwith.

R. C. H. YOUNG

FARM WATER SUPPLIES

ON October 21, under the auspices of the Society for Applied Bacteriology, a series of papers were read on various aspects of "Farm Water Supplies". The introductory paper was given by Mr. G. T. Morgan (Ministry of Agriculture and Fisheries), who at the outset emphasized the great importance of cleanliness in milk production and the significance of water supplies in this connexion. Of the 158,000 milk producers in Great Britain, 40 per cent own less than ten cows, and a large proportion still have inadequate and unsatisfactory water supplies to meet the estimated daily requirement of some 30–35 gallons per animal. With so many small units it is difficult to effect immediate improvements, particularly when so many of them have been producing satisfactory milk for many years. Information is being collected continuously, supplies are checked, and advice is given for improving their quality; reasonable time being allowed to correct faults and to effect the desired improvements.

Sir William Savage (Taunton), the eminent authority on public health matters, emphasized the need for a practical approach to the problem, since it is clear that piped supplies for all agricultural purposes are not possible, first on economic grounds and, secondly, because there is not sufficient water available. The quantities and qualities required must, therefore, be related to their uses. On only rare occasions have water supplies been incriminated in epidemics of bacterial infection, and in these cases the *Salmonella* and enteric organisms have been involved. Moreover, for most dairying purposes, the standards of water supplies need not be as high as those for general domestic supplies. Well and stream waters are quite satisfactory for animal drinking and for byre washing. Pure supplies are essential for washing all surfaces which come into direct contact with the milk. Sir William was sceptical of chemical disinfection, since this is usually carried out by unskilled farm hands.

Mr. W. A. Cuthbert (Leeds) said that 97 per cent of farm water supplies are from wells, usually shallow ones, or from springs. By means of a series of lantern slides he illustrated the unsatisfactory nature of many such wells and the difficulties of tracing the real sources of some of the springs. Infection in these waters are mainly found to be due to human pollution, which can be eliminated by appropriate protective measures, although these often involve reconstruction. Chlorination should also be employed, but this cannot be relied upon entirely to render a bad water safe. In farm water supplies, the counts of *Bact. coli* and *coli-aerogenes* groups vary independently, so that differentiation of fæcal and non-fæcal organisms is of little value for diagnostic purposes. Topographical examination of all supplies is essential and should be considered along with bacteriological findings before expressing judgment on any supply. Numerical standards for bacterial content are in themselves of no value in assessing farm water supplies because of the considerable seasonal variations encountered. Investigation has shown that factors responsible for this variation include soil temperature and, to a less extent, rainfall.

Dr. J. H. McCoy (Hull), considering the significance of polluted farm water supplies in relation to human infection, said that standard bacteriological tests cannot of themselves guarantee the non-pathogenicity of any supply. Topographical examination is a first essential to eliminate obvious faults. Epidemics of milk-borne enteric infections are traceable mainly to carriers, but a small number is undoubtedly attributed to the water supply, for example, the Croydon epidemic of 1937. Dr. McCoy also directed attention to organisms likely to cause spoilage in dairy products, such as lipolytic and proteolytic bacteria in cheeses, but said that these should not be present in large numbers in properly handled milks. Mr. T. C. Ketchen (Ministry of Agriculture and Fisheries), again emphasizing the practical and financial aspects, described in detail several ways in which the design and maintenance of farm water systems could be improved. Examples were given of how these could be effected by fencing off springs and wells from animal contact, by substituting bore-holes for shallow wells, by re-directing and piping flows from springs, or by proper walling and fencing of well-mouths.

The discussion was opened by Dr. Windle Taylor, who emphasized the importance of chemical tests on waters, and expanded further the significance of the *Bact. coli*/*coliform* ratio, stating that fæcal *Bact. coli* appears to survive much longer in water than was originally thought.

INTERNATIONAL SANITARY REGULATIONS

FOR more than a hundred years the progressive nations of the world have endeavoured to arrange a uniform sanitary code to govern international traffic and to utilize the best preventive measures against the importation of infectious diseases, especially cholera, plague and yellow fever. Important work to this end was done by the Pan-American Sanitary Bureau, the Office International d'Hygiène Publique, and the Health Organization of the League of Nations[1]. The development of air travel led to the International Sanitary Convention for Aerial Navigation, afterwards modified in 1944, like the convention of 1926 for maritime traffic.

During the first half of the present century there were as many as thirteen conventions or diplomatic arrangements relating to health control measures to be taken at frontiers. None of these conventions completely superseded all its predecessors, nor were all the States parties to these arrangements, some participating in certain of them and not in others. This disunity caused trouble and confusion in international traffic. Further defects were the delay in ratification, which prevented the application of the agreed measures rapidly and simultaneously; and

the difficulty of revising them expeditiously in the light of scientific and technical progress, experience gained and new epidemiological knowledge.

The United Nations World Health Organization was established in 1946, and in its constitution was given authority to adopt international sanitary regulations. Without delay, the Interim Commission of the Organization appointed expert committees to prepare a revision of existing sanitary conventions. They studied such questions as the sanitary control of the Mecca Pilgrimage, modern advances in epidemiology and methods of preventing transmission of disease by insect vectors. The technical documentation thus produced enabled the Expert Committee on International Epidemiology and Quarantine, with the help of its legal sub-committee, to prepare preliminary draft international sanitary regulations. In April–May 1951 these regulations were considered by the special committee appointed by the Third World Health Assembly at thirty-six plenary meetings held in the Palais des Nations, Geneva, under the chairmanship of Dr. M. T. Morgan (Great Britain). After receiving comments and suggestions from the delegates of the member States, a final draft was prepared which the special committee submitted to the Fourth World Health Assembly. The text of the Regulations was adopted unanimously on May 25, 1951, by the representatives of the sixty governments present[2].

The first part of the official record of the International Sanitary Regulations consists of the proceedings of the special committee, appointed by the Third World Health Assembly, and of the plenary session of the Fourth World Health Assembly. The second part of the volume contains the text of the Regulations with an explanatory memorandum, a table of comparison between the provisions of the Regulations and those of previous sanitary conventions and similar agreements, and an index to the Regulations. The Regulations are a revision and a consolidation of the text of the numerous previous conventions and agreements; they came into force for all member States of the World Health Organization (and also for those non-member States which so signify) on October 1, 1952.

Turning to the Regulations themselves, they are framed in the endeavour to secure maximum security against international spread of disease with minimum interference with world traffic. They revise and consolidate previous provisions on plague, cholera, yellow fever and typhus, including the Pan-American Sanitary Code, Havana, 1924. Relapsing fever, being suitable for control in ports, airports and at international frontiers, has been added. Supplementary regulations dealing with measures for preventing the spread of other epidemic diseases may be added from time to time, and already are envisaged as regards malaria.

It is required that the appearance of a quarantinable disease in a territory, and, if necessary, its continued existence, shall be notified to the Organization, which will report the information to all health administrations to which the Regulations apply. Thus health administrations will have a world-wide knowledge of the epidemiological situation of quarantinable diseases. In measures for the prevention of the importation of pestilential disease, it is intended that a State shall chiefly rely on its own public health service. The Regulations concerning plague, cholera, yellow fever, typhus and smallpox include all modern scientific methods of prevention. Vaccination is advised in the case of yellow fever; but not as regards typhus, because modern insecticides, properly applied, and disinfection where appropriate, afford adequate security. Rules governing the health control of the Mecca Pilgrimage have been added.

After reading the Regulations, including the procedure for acceptance, reservations and rejections, one obtains the impression that a great step forward has been made in the international control of epidemic disease. When all the governments of the world adopt the Regulations and implement them, they will protect not only their own frontiers from pestilence, but will also materially contribute to the health of all nations.

A. S. MacNalty

[1] MacNalty, Sir Arthur, *Nature*, **170**, 108 (1952).

[2] World Health Organization. Official Records of the W.H.O., No. 37. International Sanitary Regulations; Proceedings of the Special Committee and of the Fourth World Health Assembly on WHO Regulations No. 2. Pp. iv+443. (Geneva: World Health Organization; London: H.M. Stationery Office, 1952.) 16*s.* 3*d.*; 2.25 dollars; 9 Sw. francs.

COPYRIGHT AND THE SCIENTIST

TO the scientific man, nurtured in the tradition of the greatest possible freedom for the circulation and interplay of new scientific knowledge, anything that tends to restrict that freedom is liable to be irksome. If the Copyright Act of 1911 was guilty of causing (or more accurately of perpetuating) uncertainty among the general public as to the extent to which published works might be reproduced, it is not surprising that it should have appeared to the scientific worker to be something of a maze, any tortuous path of which might lead him to wrongdoing. Apart from such general uneasiness, three specific factors have in recent years given added point to the problem. First, and probably the least troublesome, the growth in the use made of review literature has brought out the need for some clearer definition of the degree to which a work might be quoted without infringement of the "fair dealing" provisions of the Act. Secondly, the copious increase in scientific and technical literature during the present century has brought with it a corresponding need for digests and summaries for convenient record by the research worker. Thirdly, advances in photo-copying and microphotography have simplified the reproduction of tables of results, technical reports and periodical articles and virtually removed the principal "disincentive" to copying, namely, the laborious process of manual transcription. If the Report of the Copyright Committee* set up by Mr. Harold Wilson, then President of the Board of Trade, in April 1951 does not entirely resolve these problems, it does provide a reasoned commentary on them and its recommendations will doubtless form the basis of any new legislation that may be introduced.

It says much for the good sense of scholars, authors and publishers alike that no test case has so far been brought in British courts. Yet it is virtually certain that the law of copyright, as it now stands in relation to the limited copying permissible of any work "for the purpose of private study, research, criticism, review or newspaper summary" has been frequently infringed in the scientific field. The facts that, first, infringement has probably taken place either in ignorance of the law or from a lack of understanding

* Report of the Copyright Committee, Cmd. 8662. (London: H.M.S.O. 4*s.* 6*d.* net.)

of the conception of published work as property; secondly, that no author or publisher has yet felt able to seek issue at law; and thirdly, that evidence of unlawful copying in cases of private study or research must be extremely difficult to obtain, only serve to emphasize that the present position is founded on fundamentally bad law. Two conflicting interests must be reconciled. On one hand, the scholar's interest demands that reasonable freedom to profit from the speed and cheapness of modern photographic methods of copying should be enjoyed, especially where original works are scarce or out of print. On the other, the author or his publisher—neither of whom may be responsible in these days for a work going out of print—quite reasonably foresees that indiscriminate and cheap photographic copying may substantially affect his own income.

The Copyright Committee's diagnosis of this general problem is not at fault. What is debatable is whether the formula which it puts forward as machinery for the reconciliation of these two sets of interests rests upon a proper assessment of the nature of scientific communication. Broadly speaking, the Committee attempts to differentiate between the copying of periodical literature, books and manuscripts, a distinction of form rather than of content. The assumption is made—and for the purposes of science rightly made—that considerations of speed and currency lend the greatest importance to copying from periodical publications. Here it is proposed that, subject to certain statutory rules to be drawn up in consultation with organizations directly interested, any periodical literature should be available for copying. The minimum provisions of these rules which the Committee suggests is that copying should be done only by certain specified non-profit-making bodies, that the responsible librarian should satisfy himself that copies are genuinely required for private study or research, that one copy only of any one excerpt should be supplied to any one person and the excerpt restricted to one article, that the copy should not be supplied at less than cost price and that the applicant should give a written undertaking that the excerpt will not be used for other than its declared purpose. Apart from the question of designating the bodies under which such copying would be permitted, the proposals probably recognize, and are doubtless envisaged as giving force of law to, a procedure that is already not uncommonly adopted by learned societies and research libraries. Copying from books would be treated similarly except that the rules, since speed would not seem to be so essential, would enjoin some attempt to secure the author's or his publisher's permission before any "substantial" extract was copied.

It is not, however, sufficient to distinguish only between the various forms of printed publication. A more fundamental distinction lies between types of material published and, particularly, between works of creative imagination and papers or articles which bring scientific research data to public notice. While, on one hand, the author of a creative work expects to receive payment, and indiscriminate copying would be against his interests, for the scientific man, on the other hand, publication is rarely a matter of commercial reward. The scientific man's financial return is often nil, or a merely nominal sum. His real profit is in the form of an increase in professional reputation. Indeed, his interest, like that of scientific progress, demands that his work should be circulated as widely and as freely as possible. Some such notion doubtless lies behind the common practice among learned journals of making reprints of their papers readily available to contributors; and since this indicates acceptance by a considerable body of publishers of the advantages of the system, it is difficult to see that an extension of freedom to copy from scientific papers could do material harm. It should, of course, be required that every copy so made should bear a full reference to the original publication, and re-sale should be prohibited by law.

Needless to say, a general arrangement such as this would still be open to objections. Is it certain, for example, that works of creative imagination will not occasionally come near to being properly regarded as of scientific value? Is it reasonable to give the force of law to a permissive arrangement embodied in the Royal Society's "Fair Copying Declaration", and extend its application to all commercial scientific publishers in addition to those who have already accepted its provisions, together with many learned societies and other publishing agencies? How, if at all, would any general relaxation of copyright law in relation to scientific works affect British interests abroad under existing or contemplated international copyright conventions? Awkward as they are, it should not prove impossible to reach a fair solution of these problems. At the moment, it appears as though the Committee, in trying to please research worker, author and publisher alike and in treating all publication as a commercial investment, may have fallen into the trap of proposing statutory authority for a piece of cumbersome protective machinery which was created in self-defence against an anomalous and outmoded law.

LESLIE WILSON

CHEMICAL RESEARCH LABORATORY, TEDDINGTON

REPORT FOR 1951

A PUBLICATION bearing the general title "Chemistry Research 1951"* includes the report of the Chemistry Research Board, signed by the chairman, Prof. E. L. Hirst, and the report of the Chemical Research Laboratory, Teddington, over the signature of the director, Dr. D. D. Pratt, together with the customary lists of publications during the year, standard substances and staff, and an alphabetical list of species in the National Collection of Industrial Bacteria, which now includes more than five hundred strains. Following a special review by the Board of the research programme and distribution of effort in the Laboratory, increased effort has been assigned to the purification of organic compounds and the precise measurement of physical properties, and to the microbiological production of sulphur. Work on the precise measurement of the vapour pressures and boiling points of bases of the pyridine series has been resumed, and greater effort has been given to the chemical side of the joint programme with the Physics Division of the National Physical Laboratory on accurate bomb calorimetry. A team from the Chemical Research Laboratory is now using for the microbiological reduction of sulphate the continuous process developed by the Ministry of Supply's Experimental Station at Porton.

* Department of Scientific and Industrial Research. Report of the Chemistry Research Board with the Report of the Director of the Chemical Research Laboratory for the Year 1951. Pp. iv+126+4 plates. (London: H.M. Stationery Office, 1952.) 4*s.* 6*d.* net.

Although the new Radiochemical Building of the Laboratory was expected to be ready for occupation, this would not suffice to meet the lack of accommodation stressed in the report for 1950; but that position should be alleviated by the new prefabricated building, specially designed for microbiological work, which was to be completed by the middle of 1952. (Both buildings have now been completed, see *Nature*, October 18, p. 648.) The Board's report stresses the extent to which fundamental work on corrosion is contributing to the solution of practical problems. Four model Scotch marine boilers have been installed on behalf of the British Shipbuilding Research Association for the Corrosion Group to investigate the corrosion produced in boiler tubes by the infiltration of salt water, and the Group is also advising the British Electricity Authority on the corrosion of boiler tubes in its generating stations. Use of potassium chromate containing chromium-51 in the study of corrosion inhibitors has indicated that the role of the inhibitor is not solely that of an oxidant keeping the iron oxide film in repair, and the radioactive tracer technique has already furnished information on the amount of chromium in the protective film and the distribution of the chromium over the surface. The use of electrode potential decay-curves has thrown further light on the mechanism by which sodium benzoate and potassium chromate inhibit corrosion, while good progress is reported in the fundamental work on the oxidation of massive metal surfaces. Other work has shown that sodium salts of the three nitrocinnamic acids and of *o*-nitrohydrocinnamic acid, at 0·5–1·0 per cent, inhibit the corrosion of cast iron as well as of zinc in distilled and mains water; the electrochemical investigation of the behaviour of painted steel panels in the solutions of various osmotic pressures continued, and electrochemical studies of anaerobic microbiological corrosion were started, as well as preliminary work on the effect of the cooling fluid on the turning of mild steel and on the application of vapour phase inhibitors for arresting corrosion in closed installations.

In the production and analysis of pure germanium for the Radio Research Board, the Inorganic Group has succeeded in reducing to about 1 part in 10^9 the arsenic content of germanium dioxide, produced from the tetrachloride, by distilling germanium tetrachloride in the presence of hydrochloric acid and chlorine. Further work on phosphatic fertilizers has been directed largely to the production of dicalcium phosphate and the recovery of the nitric acid used in attacking the phosphate rock. Besides a literature survey of the recovery of sulphur from calcium sulphate, the Group has continued to study the spectrophotometric determination of arsenic by the 'molybdenum blue' method; its spectrographic laboratories have been equipped with a 'multiservice unit' and a Beckman spectrophotometer with flame-photometer attachment, while efforts have been made to increase the speed of microchemical analyses of samples and to place on a sound basis the inorganic techniques required to deal with the increasing number of inorganic materials presented for analysis.

In the Radiochemical Group the scope of chromatographic methods has been extended to a wider range of metals, including tantalum and niobium, which are difficult to separate in other ways. Further improvements have been made in physical methods of analysis, and a polarographic method has been developed for continuously recording the variation in concentration of metal ions in solution, and a method devised for the measurement of carbon-14 operating in solution, based on a scintillation technique. Studies were carried out on the adsorption of gold, copper and iron from cyanide solutions by 'Amberlite I.R.A. 400' resin and of nickel, cobalt and zinc by 'ZeoKarb 225' cation-exchange resin, as well as on the precipitation of uranium and other metals from solution.

Much of the work of the Organic Group has been concerned with the provision of services to other organizations, and its preparative work has included, for example, the supply to the Medical Research Council for field trials in Africa of a sample of N_1N_5-*bis*-(4-aminocinnalyl-6-)guanidine, which has shown promising trypanocidal activity, a new synthesis of 2 : 6-hydroxybenzoic acid, the preparation and investigation of 2 : 3 : 5 : 6-tetrahydroxyterephthalic acid and its diethyl ester and attempts to prepare phloroglucinoltricarboxylic acid for investigation of its anti-rheumatic properties. Nearly five hundred samples of pure low-boiling hydrocarbons have been supplied to industrial and other laboratories in Britain for use as standards in calibrating mass spectrometers; α-picoline has been hydrogenated at 120–140° C. in the presence of *W*-6 Raney nickel catalyst, and benzene containing carbon-14 atoms has been synthesized, as well as ethylene oxide containing carbon-14 for use in insecticide studies.

The unique properties of polyvinyl alcohol membranes are being studied by the High Polymer Section for studies in osmometry and the exchange behaviour of large quaternary ammonium cations. A second series of sulphonated polystyrenes of different degrees of cross-linking has been prepared from a divinylbenzene solution supplied by the Dow Chemical Co., and the relative affinity coefficients are in general consistent with theories of ion-exchange equilibria which emphasize the importance of the size of the hydrated cation in the resin. Work has been commenced on the preparation of strongly basic resins by the chloromethylation of styrene, and, in work on the application of ion-exchange resins, β- and γ-resorcylic acids have been separated on an anion-exchange resin.

Fundamental studies in the Microbiological Section indicate that reducing agents enhance the viability of sulphate-reducing bacteria, and this finding has led to the development of a method for the accurate counting of live organisms. Work on the breakdown of organic compounds by these organisms has demonstrated the importance of pyruvic acid in their metabolism, and certain strains have been found which require no reducible sulphur when grown with pyruvates. Investigations on the inhibition of hydrogen absorption have continued, and those sulphate analogues found to be active inhibitors in manometric studies have been tested as inhibitors of the growth of the Hildenborough strain in sulphate-deficient *GPYS* medium; culture filtrates of this strain grown in *GPYS* and *LYS* media showed no trace of antibiotic activity against a wide variety of organisms. Further experiments have shown that elemental sulphur can be produced by the combined action of pure cultures of sulphate-reducing bacteria and the photosynthetic green or purple sulphide-oxidizing bacteria in a common medium and provide strong evidence that some of the sulphur in the Cyrenaican lakes was produced from sulphate by a similar combined action.

ROYAL GREENWICH OBSERVATORY

ANNUAL REPORT FOR 1951–52

THE annual report of the Astronomer Royal for the period May 1, 1951–April 30, 1952*, deals with the three separate sections of the Royal Greenwich Observatory at Herstmonceux (including H.M. Nautical Almanac Office), Greenwich and Abinger, and provides an account of the work carried out at each place as well as a short description of the condition of the buildings. In some cases the progress of repair and reconstruction leaves much to be desired.

Approval has been given to the recommendation of the Board of Visitors that the old buildings of the Royal Observatory at Greenwich should be used as an astronomical and navigational annexe to the National Maritime Museum, and the trustees of the latter have received official intimation of this recommendation. The Astronomer Royal proposes leaving the historic instruments belonging to the Observatory in the old buildings at Greenwich—a decision which will give wide public satisfaction. The progress of the work with the 36-in. Yapp reflector at Greenwich has been disappointing, owing to further deterioration in the sky since the end of the Second World War, largely due to street lighting with mercury-vapour lamps, recently installed; a further reduction in the output of the telescope has been caused by illness among the observers. The programme of examining *K*0 sub-giants for luminosity effects correlated with anomalous trigonometric parallaxes is now directed towards fainter stars, and this, with the other factors, is responsible for the fact that only forty-six spectra of thirty stars have been obtained with the main reflector.

Time service throughout the year has been based upon astronomical observations made with the small transit *B* at Greenwich and the Bamberg broken-transit instrument at Abinger. A total of 509 observations at both places was made in the twelve months covered by the report, and an analysis of the performance of the clocks suggests that considerable changes occur in phase and amplitude of the annual fluctuations in the rate of rotation of the earth. The values obtained for 1950–51 are smaller than those given by many previous concordant analyses, and hence it is not practicable to apply corrections month by month to the time determined astronomically so as to produce a uniform time system. A time system that is approximately uniform is defined by the best quartz clocks, while the astronomical determinations of time over two or three years are used for giving the error and the rate for each clock.

Preliminary work has been started on the preparation of the Admiralty magnetic charts for the epoch 1955; the unfortunate dearth of recent observational data over many parts of the earth, particularly in central Asia and in the oceans, renders it extremely difficult to construct reliable current charts of secular variation. The employment of spherical harmonic analysis to improve the charts in regions where no observations have been made cannot be regarded as very satisfactory; the process is one of distributing the inaccuracies and is a poor substitute for the deplorable lack of observational data.

An important collaboration between H.M. Nautical Almanac Office and the Nautical Almanac Office, United States Naval Observatory, has resulted in the British "Air Almanac" and the "American Air Almanac" becoming a single publication bearing the title "The Air Almanac". Although printed separately in Great Britain and the United States, the two editions are printed photographically from identical material. This production represents a very important step in international co-operation, and the United States authorities have agreed to supply, at nominal cost, specially pulled proofs on glossy paper suitable for photographic reproduction to the official almanac-producing agency in any country. The International Civil Aviation Organization has recently directed the attention of contracting States to the availability of this Almanac for reproduction in other countries, with or without language changes, and it is hoped that it may eventually become international.

Some disappointment is expressed in the report at the slow progress in the removal of the Observatory from Greenwich to Herstmonceux. Nearly four years have passed since the first sections of the staff were moved to Herstmonceux; but the only instruments that have been installed are the spectroheliograph and spectrohelioscope, and the 26-in. and 28-in. refractors still remain dismantled at Herstmonceux. The Cook reversible transit circle is still at Greenwich, but no large programme of observations will be started with it until it has been installed at Herstmonceux. Increased industrial staff and, in consequence, increased expenditure attend the separation of the Observatory into three separate sections at Herstmonceux, Greenwich and Abinger, and, in addition, there is loss of flexibility and much administrative inconvenience. The most serious disadvantages of the division are the loss of observations and the lack of training in observing by many junior members of the staff. The meridian group, which is already far behind schedule, is to be proceeded with, but the financial cuts imposed this year have prevented a start on the construction of the equatorial group. The general situation is summed up by the Astronomer Royal towards the end of the report in the following words: "The slow progress in the removal from Greenwich to Herstmonceux is the cause of great disappointment and of a deep sense of frustration".

*Report of the Astronomer Royal to the Board of Visitors of the Royal Greenwich Observatory, read at the Annual Visitation of the Royal Observatory, June 7, 1952. ‡Pp. 30. (Greenwich: the Observatory, 1952.)

STANDING LIGHT WAVES

THE Rumford Medals awarded biennially by the American Academy of Arts and Sciences to the outstanding American contributors to the science of heat and light were established in 1796 by a gift of Benjamin Thompson, Count Rumford. It is customary for the recipient to present a communication to the Academy at the time of the receipt of the Medal, and in recent years he has usually reviewed significant aspects of his own work. The Academy, believing that the communications constitute a noteworthy record of American achievement in heat and light, has decided to publish a new series of the biennial Rumford Lectures, and the first of this series*, entitled "Adventures with Standing Light Waves", is by Prof. H. E. Ives, who was awarded the Rumford Medal for 1951.

Proc. Amer. Acad. Arts Sci., **81**, No. 1 (1951); "Adventures with Standing Light Waves" (Rumford Medal Lecture, 1951) (pp. 32; from the Academy, Boston, Mass., 1951).

The phenomenon of standing waves of light in the form of the Lippmann process was the subject of Prof. Ives's doctoral thesis some forty years ago. He then turned, during the First World War, to work on aerial photography, and after the War at the Bell Telephone Laboratories he was occupied at first with electrical contacts and then with the photoelectric effect, of which he made a close study. The various problems in the nature of the photoelectric effect, particularly the effect of the state of polarization of the exciting light on the photoelectric emission and the spectral distribution of the photoelectric emission from the alkalis, occupied his attention and led him to give an explanation in terms of the existence of a system of standing waves above the metal surfaces. This required for its test a knowledge of the optical constants of the alkali metals. Details of the experimental results obtained and their significance are discussed briefly by Prof. Ives. He stresses that it is the optical properties of the materials and the optical conditions of the region in which the phenomena occur which explain the outstanding effects, and that the various quantum mechanical explanations have almost uniformly neglected or ignored the optical factors.

Another experiment with standing waves of light referred to by Prof. Ives is a modification of Wiener's experiment, with a photoelectric film replacing the photographic film used by Wiener. Prof. Ives asserts that the verification of the electromagnetic wave theory of light furnished by this experiment considerably transcends that of Wiener's original simple experiment.

Finally, Prof. Ives discusses what contribution the results of these photoelectric experiments can make to the elucidation of the old question of the nature of light, waves versus corpuscles. Wiener's modified experiment, he claims, comes very close to showing both types of phenomena in combination. Wave mechanics is a way out of the dilemma. It avoids the unacceptable idea of photons by putting the quantum h in the atom and not in the radiation, and Prof. Ives concludes by predicting that the photon will go the way of the 'calorie' that Rumford demolished.

X-RAY AND NEUTRON MUTAGENIC EFFECTS ON CEREAL SEEDS

THE biological action of X-rays and fast neutrons on cereal seeds is the subject of detailed investigation in the Mutation Laboratory of the Swedish Seed Association at Svalöf, Sweden, use being made of the cyclotron equipment and other facilities of the Nobel Institute for Physics and of the Institute of Radiophysics at Stockholm (J. Mackey, *Arkiv. för Botanik*, **1**, 16, 545; L. Ehrenberg, A. Gustafsson and N. Nybom, *ibid.*, 557, 1952).

Both dry dormant and soaked seeds of wheat and barley were irradiated with X-rays and fast neutrons and the treated materials followed through two generations for observation of the frequency of primary chromosome disturbances, the retarding effect on sprouting, the death-rate, the induced degree of sterility in the first generation, and the frequency of certain types of mutation in the second. For the production of genetically interesting and useful materials, neutrons are many times more effective than X-rays; at high neutron dosages the mutation-rate reaches a very high level. Cells with low water content (and low metabolic activity) are highly resistant to the killing effects of neutrons as compared with X-rays, but actively dividing cells are more sensitive to neutrons; after neutron irradiation, about five times as many cells show chromosome disturbances in pre-soaked as compared with dry seed.

Different radiations may act in different ways because of differences in ionization density, distribution of ionizing rays within the object, and the duration of the time of action of isotopes. The general result so far obtained is that neutrons are about ten times as effective as X-rays of equivalent energy dissipation in causing chromosome disturbances and from fifty to one hundred times as effective in causing first-generation sterility and in increasing the rate of mutation. This higher effectiveness is attributed to the difference in ion density. While the results reported are not regarded as final, they constitute an important advance in the planned and controlled induction of mutations in agricultural and horticultural plants by ionizing agents.

CYTOCHROME COMPONENTS IN CHLOROPLASTS

By H. E. DAVENPORT

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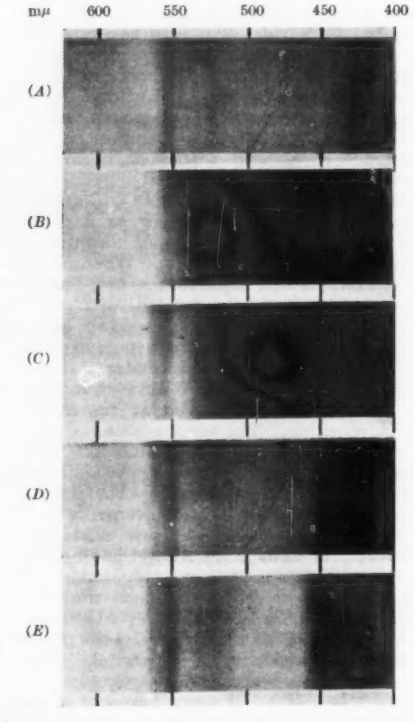
LITTLE was known of the distribution of components of the cytochrome system in green leaves until Hill and Scarisbrick[1] separated not only cytochrome *c* but also two new soluble components, b_5 and *f*. Cytochrome *f* appeared to be confined to chlorophyll-containing tissues where the presence of high concentrations of plastid pigments precludes the direct spectroscopic observation of the component. It was first observed in the reduced form in preparations of leaves from which plastid pigments had been removed by acetone treatment. Afterwards, Hill and Scarisbrick obtained cytochrome *f* in solution in ethanol extracts of fresh leaves. In solution it is not autoxidizable, does not combine with carbon monoxide and has, in the reduced form, a characteristic spectrum with the α-band at 555 mμ. Further properties of the purified cytochrome have been described in greater detail[2] and evidence presented for supposing that it may play an important part in the electron transfers occurring in photosynthesis. Hitherto, however, cytochrome *f* has been observed only in preparations which had been treated with organic solvents, and the possibility therefore remained that it was an artefact arising from some other hæmatin compound as a result of that treatment. It has now been found that the absorption spectrum of cytochrome *f* can be observed directly in intact plastids prepared from etiolated barley leaves.

Barley seedlings were grown on John Innes seedling compost in a darkened incubator at about 20° C. After nine days, the yellow leaves were harvested and 10-gm. amounts were ground in a chilled mortar with 10 ml. of cold 0·5 *M* glucose in 0·03 *M* phosphate buffer of *p*H 7·4. The material was squeezed through muslin and centrifuged for 1 min. at 3,000 r.p.m. to remove intact cells and vascular debris. The turbid yellow supernatant fluid was centrifuged at 4,000 r.p.m. at 2° C. for a further 5 min. This gave a yellowish brown sediment which when viewed

with the Zeiss microspectroscope against a strong light showed the spectra of carotenoids, protochlorophyll and a little chlorophyll *a* and also a sharp band at 555 mμ, the position of the α-band of ferrocytochrome *f*. The cloudy supernatant fluid was recentrifuged at 12,000 r.p.m. for 10 min. to give a second precipitate showing a similar spectrum.

The two precipitates were suspended separately in about two volumes of the cold glucose solution and examined microscopically. The second precipitate appeared to be mainly fragments of plastids, whereas the first precipitate consisted of intact plastids similar in form to the chloroplasts extracted from normal green barley leaves by the same procedure. The latter have been found to have high activities in the photochemical chloroplast reaction described by Davenport, Hill and Whatley[3]. Similarly[4] it has been shown that etiolated barley plastids will reduce an indophenol dye in light, and that this activity increases progressively with the development of chlorophyll when the leaves are greened by exposure to light. For further examination and the photography of spectra, the suspended precipitates were combined in a cell 0·5 cm. thick. The photographs of absorption spectra were made in collaboration with Dr. R. Hill, using a diffraction-grating camera arrangement designed by him[2].

Immediately after resuspension of the precipitates, the band at 555 mμ is relatively faint; but at room temperature it slowly increases to a maximum density in about 30 min. (Fig. *B*). Shaking then again results in an immediate decrease in density, suggesting that



Absorption spectra of cytochrome components. (*A*) Dilute solution of cytochrome *f*. (*B*) Suspension of etiolated barley plastids in air. (*C*) Suspension of etiolated barley plastids + sodium hyposulphite. (*D*) Compressed baker's yeast, 1 mm. thickness. (*E*) Granule preparation from pigeon breast muscle

systems are present which can catalyse the oxidation of cytochrome *f* by oxygen. On the addition to the suspension of a trace of ferricyanide, the band at 555 mμ disappears as the cytochrome is completely oxidized. If, on the other hand, a trace of a reducing agent (sodium hyposulphite) is added there is no change in the band of ferrocytochrome *f*, but two additional bands then appear (Fig. *C*) : a faint band at 605 mμ corresponding to cytochrome *a* of yeast and a strong band at 563 mμ in the position of the *b* group of cytochromes. Cytochrome *c* could not be detected visually in the preparations. To facilitate comparison of the spectrum of the reduced plastids with more typical cytochrome systems, the spectra of reduced yeast cells and muscle granules[5] are shown in Figs. *D* and *E*. By comparing visually the intensities of the α-bands of the components in the reduced plastid suspension with those in a variable thickness of compressed baker's yeast, it was possible to obtain an approximate measure of the relative concentrations of the components in the two types of material. Here it was necessary to compare the band of cytochrome *f* in the plastids with that of cytochrome *c* in the yeast. On the basis of the absorption spectra of the two cytochromes in solution this comparison is valid[2]. These measurements gave the following concentration ratios : *a* (yeast)/*a* (plastids) = 10 ; *b* (yeast)/*b* (plastids) = 1·6 ; *c* (yeast)/*f* (plastids) = 4. The concentration (v/v) of plastids in the suspension used was similar to that estimated for the living cell[1]. Moreover, Hill and Scarisbrick[1] have shown that leaf hæmatin is concentrated largely in the plastids and is not distributed evenly through the cell. These ratios may therefore be held to represent a direct comparison of the concentrations of the components in the living cells of leaves and yeast.

The spectrum of the reduced plastid preparation does not change in an atmosphere of carbon monoxide. By adding an equal volume of pyridine to the reduced suspension, bands of the corresponding pyridine hæmochromogens appear with centres at 585 mμ (*a*), 558 mμ (protohæmochromogen = *b*) and 551 mμ (*f*). The presence of large concentrations of carotenoid pigments in the preparations entirely prevented observation of the β- and γ-bands of the cytochrome components.

It was confirmed that cytochrome *f* can be extracted by ethanol from both etiolated and normal barley leaves. Leaves (10 gm.) were ground in a chilled mortar with 9 ml. of 96 per cent ethanol containing 0·06 ml. of ammonia solution (spec. grav. 0·88). The material was squeezed through muslin and centrifuged. When viewed with the microspectroscope in a layer 2 cm. thick, the characteristic band at 555 mμ was visible in the clear supernatant fluid.

The above preliminary observations appear to confirm that cytochrome *f* is a normal constituent of the chloroplast. Its abundance in the intact plastids and the relative absence of cytochrome *c* is in marked contrast to the considerable uniformity shown by the cytochrome systems of animal tissues and yeast and also by the colourless, non-photosynthesizing portions of higher plants[7,8]. There is still no direct evidence of the role of the component in the metabolism of the chloroplast; but it is hoped that further work with partially etiolated material may throw light on this problem.

I have to express my gratitude to Dr. R. Hill for his interest in this work. I am indebted to Mr. J. B. Chappell for a preparation of muscle granules. Thanks

are also due to the Agricultural Research Council for providing the special facilities for this work.

[June 4.

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OCCURRENCE OF GAMMA-AMINO-BUTYRIC ACID IN EXTRACTS OF *PISUM SATIVUM* (L.) AND IN THE HONEYDEW OF *MYZUS CIRCUMFLEXUS* (BUCK.)

By J. L. AUCLAIR and J. B. MALTAIS

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THE occurrence of gamma-amino-butyric acid in biological material has been reported occasionally. Dent[1] mentioned its possible occurrence in human blood and urine. Steward *et al.*[2] definitely identified it as a constituent of the potato tuber; next to the amides glutamine and asparagine, it was the most abundant soluble nitrogen constituent in the potato, amounting to 540 μgm. per gm. of fresh tuber. Awapara *et al.*[3] and Roberts *et al.*[4] reported the occurrence of free gamma-amino-butyric acid in the human brain. Reed[5] also found this compound in yeast.

In investigations on the factors of plant resistance to insects, analyses of free amino-acids in pea-plant extracts were carried out by paper partition chromatography. Two-dimensional chromatograms yielded a large number of amino-acid spots, one of which appeared at the position usually occupied by methionine sulphoxide (Fig. 1, No. 14). Before a further test, a few plant extract samples were oxidized at mild heat with hydrogen peroxide and a catalyst in order to convert methionine sulphoxide quantitatively into methionine sulphone. The test revealed only a trace of the sulphone on the two-dimensional chromatograms. The large methionine sulphoxide spot remained mostly unchanged. This observation led to some uncertainty as to the identity of the methionine sulphoxide spot. The R_F values of this particular spot were 0·73 in phenol – water and 0·21 in collidine – lutidine – water by the method of capillary ascent. Other samples were run with the following solvent system: phenol – water in the first dimension and *n*-butanol, 300 ml.; glacial acetic acid, 60 ml.; and water, 140 ml., in the second dimension. This procedure resulted in the separation of the 'methionine sulphoxide' spot into two components: a faint spot that remained at the methionine sulphoxide position with an R_F of 0·31 in butanol – acetic acid – water (Fig. 2, No. 14), and a large dense spot that appeared just below the valine spot with an R_F of 0·50 (Fig. 2, No. 20). The position of this new spot did not correspond with that of any of the well-known amino-acids.

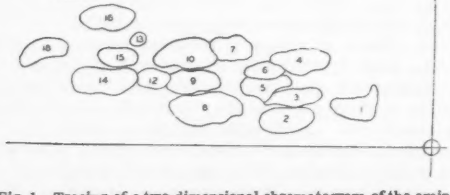

Fig. 1. Tracing of a two-dimensional chromatogram of the amino-compounds in pea-plant extract. Longest dimension in phenol – water; second dimension in collidine – lutidine – water. The numbers referring to individual amino compounds are as follows: 1, aspartic acid; 2, lysine; 3, glutamic acid; 4, serine; 5, asparagine; 6, glycine; 7, threonine; 8, arginine; 9, glutamine; 10, alanine and an unidentified compound; 11, tyrosine; 12, β-alanine; 13, α-amino-butyric acid; 14, methionine sulphoxide and γ-amino-butyric acid; 15, possibly β-amino-isobutyric acid; 16, valine; 17, leucine and/or isoleucine and phenylalanine; 18, proline

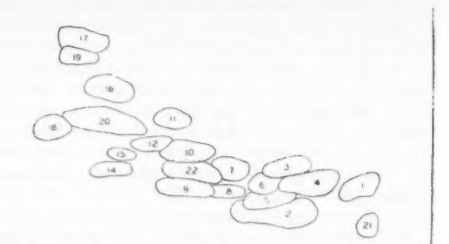

Fig. 2. Tracing of a two-dimensional chromatogram of the amino-compounds in pea-plant extract. Longest dimension in phenol – water; second dimension in butanol – acetic acid – water. The numbers referring to individual amino compounds are as follows: 1, aspartic acid; 2, lysine; 3, glutamic acid; 4, serine; 5, asparagine; 6, glycine; 7, threonine; 8, arginine; 9, glutamine; 10, alanine; 11, tyrosine; 12, β-alanine; 14, methionine sulphoxide; 15, possibly β-amino-isobutyric acid; 16, valine; 17, leucine and/or isoleucine; 18, proline; 19, phenylalanine; 20, γ-amino-butyric acid; 21, cystine; 22, an unidentified amino compound concealed by alanine in Fig. 1

The basic copper carbonate ($CuCO_3$, $Cu(OH)_2$) test described by Crumpler and Dent[6] as a distinctive test for alpha-amino-acids in paper chromatography was applied with positive results. When samples of pea-plant extracts were separated on two-dimensional chromatograms previously treated with the basic copper carbonate powder, a single spot appeared after the ninhydrin reaction. This single spot, on chromatograms irrigated with phenol – water in the first dimension and collidine – lutidine – water in the second dimension, was situated at the methionine sulphoxide position. The results obtained with the basic copper carbonate test indicated that the unidentified compound is not an alpha-amino-acid.

Of the new amino-compounds other than alpha-amino-acids recently reported as occurring in biological material, gamma-amino-butyric acid and beta-amino-isobutyric acid were those having the R_F values closest to the methionine sulphoxide position. Pure samples of the two compounds were secured, and the above experiments were repeated; gamma-amino-butyric acid matched exactly the R_F of the methionine sulphoxide spot in phenol – water and collidine – lutidine – water chromatograms. Moreover, upon the addition of a small amount of gamma-amino-butyric acid to pea-plant extracts before chromatographic analysis, there was a significant increase of the 'methionine sulphoxide' in the first solvent system and of the 'below valine' spot in the

second solvent system. These results, together with the evidence given by the basic copper carbonate test, leave no doubt as to the presence of gamma-amino-butyric acid in the pea plant. This amino-acid is an addition to the list of those identified in peas by Auclair and Maltais[7].

Gamma-amino-butyric acid was also identified in the honeydew excreted by *M. circumflexus* feeding on potato plants. It is very likely that the aphids take this compound from the host plant, which contains a relatively large amount of it. A complete chromatographic analysis of amino-acids in the honeydew of this insect feeding on potato has been effected by Maltais and Auclair[8].

A quantitative estimation of gamma-amino-butyric acid in pea-plant extracts was made by the method of quantitative paper chromatography developed by Auclair and Dubreuil[9]. On a dry-weight basis, the quantity of gamma-amino-butyric acid is approximately 11 mgm. per gm. of pea-plant sample. On a fresh-weight basis, the amount is approximately 1,680 μgm. per gm. The amount found in the potato tuber, as given by Steward *et al.*[2], is 540 μgm. per gm. In the honeydew of *M. circumflexus* feeding on potato, the quantity of gamma-amino-butyric acid is estimated at 0·6 mgm. per gm. of dry matter. The significance of the occurrence of this compound in relation to plant resistance to insects is being studied.

It is probable that another spot appearing above methionine sulphoxide, not as yet identified on chromatograms of pea-plant extracts, may be beta-amino-isobutyric acid. The R_F of this compound corresponds to the spot above methionine sulphoxide (Fig. 2, No. 15). Further tests are being carried out on its identification.

We are grateful to Dr. F. C. Steward and Dr. J. F. Thompson, Department of Botany, Cornell University, for their generous supply of pure gamma-amino-butyric acid. Thanks are also extended to Dr. Lester J. Reed, Department of Chemistry, University of Texas, for a gift of pure synthetic beta-amino-isobutyric acid. [Feb. 14.

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PEPSINOGEN IN HUMAN SEMINAL FLUID

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EARLIER investigations have shown the presence in human semen of proteolytic enzymes responsible for the degradation of the fibrin-like material which causes the clotting of semen (Lundquist[1]). The presence of at least two different proteolytic enzymes, an amino peptidase hydrolysing leucinamide, glycylglycine, triglycine and glycyl-leucine, and a 'protease' has been established[2].

We have now been able to show that apart from these enzymes, with a *p*H optimum around 7·5, there is also present in seminal fluid an enzyme which has optimal activity at very acid reaction, namely, about 2·5. As it was considered unusual for a cathepsin to show activity at such high hydrogen-ion concentration, the possibility was investigated that the enzyme in question was pepsin, or some closely related proteolytic enzyme.

Figs. 1 and 2 show a comparison of the *p*H-activity curves for the seminal enzyme preparation and ordinary swine pepsin, using as substrates serum proteins (as described by Bucher[3]), and edestin (prepared from hemp seed according to Bailey[4]). The hydrolysis was followed colorimetrically with phenol reagent and copper sulphate[5]. The very close relationship with pepsin was confirmed by the fact that coagulation of milk was produced by enzyme preparations that had been acidified and neutralized again.

The enzyme preparations employed in these experiments were purified in the following way: pooled samples (50–70 ml.) of seminal plasma (we are indebted to "Sygekasselægernes organisations centrallaboratorium" for considerable quantities of human semen) are precipitated between 40 and 70 per cent saturation with ammonium sulphate at *p*H 6. The precipitate is dialysed thoroughly against distilled water for at least 24 hr. The residue, after centrifugation, contains practically all the pepsinase activity present in the original semen and no activity at neutral *p*H, whereas the supernatant contains the other proteolytic enzymes. Extracts of the precipitate with 0·9 per cent sodium chloride are used for further experiments. Extracts prepared in this way contain the enzyme as a proenzyme, which is converted to pepsin when the *p*H is lowered to 3–4. This was shown by the following experiments:

(*A*) *Milk coagulation test.* When the solution is mixed with skim milk at *p*H 5·4 (0·1 ml. enzyme + 1 ml. milk) no coagulation takes place. If the enzyme solution is acidified to *p*H 2 and carefully readjusted to *p*H 5·4 after a few minutes, coagulation takes place 2 min. after mixing with milk.

(*B*) *Instability in alkaline solution.* When the extract prepared as described above is kept at room temperature for 18 hr. at a *p*H of 8·5, no appreciable reduction in activity takes place. If, however, before

ENZYMATIC ACTIVITY OF HUMAN SEMINAL ENZYME, HUMAN GASTRIC JUICE PEPSIN AND CRYSTALLINE SWINE PEPSIN TOWARDS DIFFERENT SUBSTRATES

Substrate	Seminal enzyme (0·34 mgm. nitrogen/ml.)	Human gastric enzyme	Crystalline swine pepsin (0·0029 mgm. nitrogen/ml.)	Ratio: gastric enz. / seminal enz.
Serum protein (extinction)	average 0·206 0·208 0·209	average 0·212 0·217 0·222	average 0·215 0·218 0·221	1·04
Edestin (extinction)	0·174 0·178 0·181	0·185 0·184 0·183	0·195 0·198 0·201	1·035
Milk (1,000/clot. time)	8·02 7·71 7·85 7·82	8·32 8·29 8·25	8·40 8·45 8·50	1·055
Carbobenzoxyglutamyltyrosine (per cent hydrolysis)	60	62	60	1·03

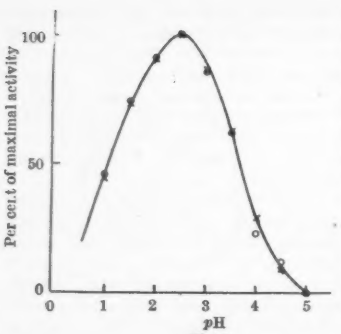

Fig. 1

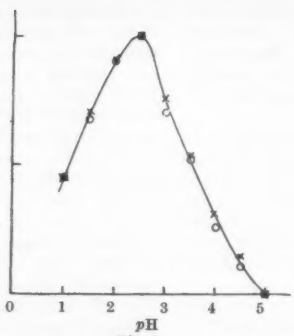

Fig. 2

Fig. 1. Activity of seminal enzyme (circles) and swine pepsin (crosses) as a function of *p*H. Substrate, 10 per cent dialysed dry serum; 2 ml. substrate + 0·5 ml. enzyme. Temperature, 37° C. Time, 60 min. Citrate buffer. Activity expressed as per cent of the maximal value

Fig. 2. Activity of seminal enzyme (circles) and swine pepsin (crosses) as a function of *p*H. Substrate, 2 per cent edestin in citrate; 2 ml. substrate + 0·5 ml. enzyme. Temperature, 37° C. Time, 60 min. Activity expressed as per cent of the maximal value

incubation the *p*H has been brought to 2·5 and back to 8·5, practically all activity has disappeared. This instability at faintly alkaline and even neutral reaction is a characteristic property of pepsin.

The accompanying table shows the results of experimental comparison of the activity towards various substrates of seminal pepsinase, crystalline swine pepsin and human pepsin made from gastric juice. The enzymes were diluted to approximately the same strength towards serum protein. For the serum protein, 2 ml. of a 10 per cent dialysed solution of dry serum at *p*H 2·5 was incubated with 1 ml. enzyme for 1 hr., followed by precipitation of proteins with trichloroacetic acid and phenol reagent and addition of copper sulphate and sodium carbonate to an aliquot of the filtrate. Edestin was used in the same way, but the concentration of protein was only 2 per cent; colour was developed in the same way as for serum proteins. For the milk test, 0·1 ml. of enzyme was added to 1 ml. of skim milk at *p*H 5·4, and the time was measured for the first sign of flocculation. In the test with carbobenzoxy-glutamyl-tyrosine, the substrate concentration was 0·0015 *M* and the *p*H 2·5; the samples were incubated at 37° C. for 18 hr. and deproteinized with tungstic acid; the hydrolysis in this case was measured by the ninhydrin method as described recently by Baker[6]. The close similarity in the rates of hydrolysis is best seen when the ratio between human gastric pepsin and seminal pepsin for the four substrates are compared (last column).

The activity of pepsinogen in normal semen corresponds to 0·002 mgm. pepsin per ml., which is of the same order of magnitude as that found in gastric juice.

As pepsin was one of the first enzymes to be prepared in the crystalline state, we tried to crystallize the enzyme from human semen. The methods described by Northrop[7] were not applicable in our case, because they require very concentrated solutions; but the following procedure led to the crystallization of seminal pepsin. The saline extract (already described) was dialysed against distilled water for 36 hr. The precipitate was extracted with isotonic saline and centrifuged for 20 min. at 25,000 *g*. The supernatant was again dialysed, and the small amount of precipitate extracted with 0·05 *N* hydrochloric acid. The clear supernatant after centrifugation for 30 min. at 25,000 *g* was dialysed for 24–48 hr. at 5° C. against distilled water. By this procedure crystals were obtained. They have not been isolated free of amorphous material, and the quantities of crystalline enzyme are exceedingly small, so that we have not so far been able to make analyses and to tackle the question of the identity of pepsin from semen and gastric juice. The crystals are, however, indistinguishable both as regards appearance and size from those prepared from pure swine pepsin using the same procedure, and correspond well with the description given by Northrop (compare Fig. 3).

Concerning the site of formation of pepsinogen, our preliminary experiments indicate that it is formed in the vesicular glands. The function of pepsinogen in semen presents a very puzzling problem, the main difficulty being how activation takes place. It must be considered very improbable that the *p*H of semen at any time after ejaculation into the female genital tract can be exposed to *p*H values low enough to bring about activation. If, on the other hand, activation has taken place, one might imagine some process analogous to milk coagulation, which takes place at more physiological *p*H values.

One possibility has appealed to us, namely, that pepsinogen is adsorbed to the surface of the sperm cells, and that the acid metabolic products excreted by the cells might bring about a local high acidity, enabling the proenzyme to be converted into pepsin. Experiments with epididymal bull spermatozoa have shown, however, that less than one thousandth of the cell surface is covered with pepsinogen when a dense suspension of living cells is mixed with pepsinogen solution. Work on this problem will be continued on other animal species.

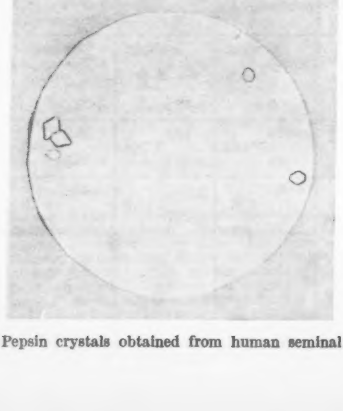

Fig. 3. Pepsin crystals obtained from human seminal plasma

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LETTERS TO THE EDITORS

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Determination of Neutron Resonance Parameters from Measurements of the Absorption Integral : Application to the Main Resonance of Uranium-238

THE resonance absorption of neutrons has been extensively studied by the time-of-flight technique[1]. If the resolution is insufficient to resolve the true shape of the resonance curve, it is sometimes possible to determine the absorption cross-section σ_0 at exact resonance and the width Γ of the Breit–Wigner resonance formula from a study of the variations with absorber thickness of the absorption integral :

$$A(n) = \int(1 - T)\mathrm{d}E = \int(1 - \exp - n\sigma(E))\,\mathrm{d}E, \quad (1)$$

where $\sigma(E)$ is the cross-section of the absorbing nuclei and n the number of nuclei/cm.^{2}. Experimentally, the absorption integral is found as the area of the dip in the measured curve of transmission against neutron energy. This area is independent of the resolution.

If the resonance is sharp, that is, the width is small compared to the resonance energy, the asymptotic behaviour of $A(n)$ for large n has been shown to be

$$A_{as} = (\pi n\sigma_0\Gamma^2)^{1/2}. \quad (2)$$

In treating the results of absorption integral measurements, it is convenient to express them in the form :

$$y = (A/A_\infty)\,(n_\infty/n)^{1/2}, \quad (3)$$

where A_∞ results from the measurement on an infinitely thick absorber. If the Breit–Wigner formula is assumed to hold and the resonance is sharp, we have for atoms at rest :

$$y_0 = (4\pi n\sigma_0)^{-1/2}\int_{-\infty}^{+\infty}[1 - \{\exp - n\sigma_0/(1 + x^2)\}]\,\mathrm{d}x$$

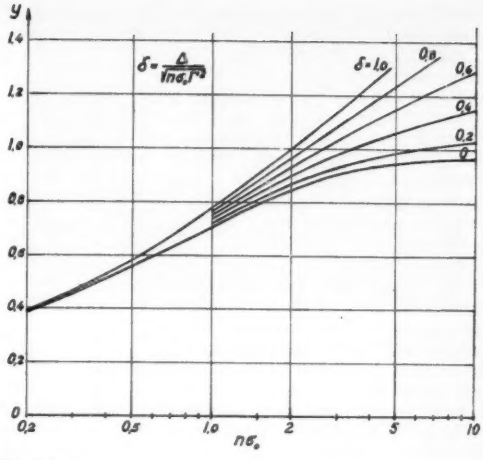
$$= (\pi n\sigma_0)^{-1/2}\int_0^z\int_{-\infty}^{+\infty}\{\exp - 2t/(1+x^2)\}\,(1+x^2)^{-1}\,\mathrm{d}x\mathrm{d}t$$

$$= (\pi/2z)^{1/2}\int_0^z(\exp - t)\,I_0(t)\mathrm{d}t$$

$$= (\pi z/2)^{1/2}\,(\exp - z)\,[I_0(z) + I_1(z)], \quad (4)$$

where $z = n\sigma_0/2$.

The intermediate step leading to the introduction of a Bessel function $I_0(z)$ of imaginary argument makes use of the integral expression quoted by Bethe[2]. The final result is obtained by partial integration[3]. The function y_0 has previously been calculated by numerical integrations by Havens and Taylor[4]. If the width Γ of the resonance cannot be regarded as large compared with the Doppler width Δ, the Breit–Wigner cross-section curve has to be averaged over the velocity distribution of the scattering atoms.



We have :

$$y = (4\pi n\sigma_0)^{-1/2}\int_{-\infty}^{+\infty}[1 - \{\exp - n\sigma_0\psi(\Gamma/\Delta, x)\}]\mathrm{d}x, \quad (5)$$

where[2]

$$\psi(\Gamma/\Delta, x) = \pi^{-1/2}\,(\Gamma/2\Delta)\int_{-\infty}^{+\infty}[\exp - \{(\Gamma/2\Delta)(x-y)\}^2]\,(1+y^2)^{-1}\,\mathrm{d}y. \quad (6)$$

The integrations (5) and (6) can no longer be carried out analytically, but it is possible by series expansion of the integrands of (5) and (6), and subsequent integration term by term, to obtain y in the form of a power series of δ^2, where

$$\delta = \Delta/(n\sigma_0\Gamma^2)^{1/2}. \quad (7)$$

This power expansion will converge only as long as $\Delta/\Gamma < 1$. For larger values of Δ/Γ the integrations (5) and (6) have been performed numerically. In the accompanying graph, y is plotted as a function of $n\sigma_0$ with δ as a parameter.

For very thick samples ($n\sigma_0 \gg 1$) the expansion

$$y_{as} = 1 - \frac{1}{4}(2z)^{-1} - \frac{3}{32}(2z)^{-2} \ldots + \frac{3}{2}\delta^2\left(1 - \frac{5}{4}(2z)^{-1} \ldots\right) - 45/8\,\delta^4 \ldots \quad (8)$$

is obtained.

To determine the resonance parameters from measurements of the resonance integral for a thin and a thick sample, the thick sample is first assumed to be infinitely thick and δ and y for the thin sample calculated. The graph then gives a first approximation to σ_0. From this the function y for the thick sample is calculated using (8) and is applied as a correction factor to δ and y for the thin sample, yielding a second approximation for σ_0.

For optimum accuracy the thickness of the thin sample should be chosen roughly in the region of

Sample (gm./cm.^{2})	n (cm.$^{-2}\times10^{24}$)	A (eV.)	y	δ	$n\sigma_0$	σ_0 (cm.$^2\times10^{-24}$)
5·46	0·0115	0·670 ±0·050	1·00	0·14	(53)	
3·45	0·00727	0·560 ±0·040	1·05	0·17	(34)	
0·67	0·00144	0·265 ±0·030	1·12	0·39	>3·3	>2,000
0·27	0·00051	0·170 ±0·025	1·14	0·62	2·3 –10·5	4,000–18,000
0·092	0·000194	0·065 ±0·010	0·75	1·06	0·60–1·30	3,100–6,700

maximum slope of the graph, if it is assumed that the absorption integral measurements have the same absolute accuracy. For atoms at rest this corresponds to a value of $n\sigma_0$ of about 1·0, while the Doppler effect tends to increase the optimum thickness. If the thin sample is made very thin, the result becomes independent of the Doppler effect, but the accuracy is low.

The procedure has been applied to measurements on the main resonance of uranium described elsewhere[5]. The samples were uranium oxide of thicknesses listed in column 1 of the table. Uranium oxide has a Debye temperature of about 140° K.[6], and the effective temperature[7] of the sample is thus almost equal to the room temperature, the Doppler width Δ being 0·052 eV., assuming a resonance energy of 6·6 eV.[5,8]. The value of σ_0 has been given in the last column as an upper and lower limit resulting from estimated mean square errors of the absorption integral measurements. While the accuracy of the measurements is rather low, it is seen that the results are quite consistent.

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Angular Distribution of the Neutrons from the Reaction ^{7}Li(*d*,*n*)^{8}Be

Using 680-kV. deuterons from the Van de Graaff generator at the University of Bergen, we have measured the energy spectrum and the angular distribution of the neutrons from the reaction ^{7}Li(*d*,*n*)^{8}Be. The energy spectrum of the neutrons has been found by measuring the recoil protons in photographic emulsions for the following angles ω, between the *d* and *n* directions in the laboratory system: 0°, 20°, 50°, 90°, 110°, 120° and 140°. A total of about 10,000 proton tracks, forming a maximum angle of 10° with the incident neutrons, have been investigated.

The energy spectrum for $\omega = 140°$ is given in Fig. 1. Neutron groups are found corresponding to energy-levels in beryllium-8 at 2·9, 4·1 and 5·0 MeV. These results are in good accordance with previous measurements by Green and Gibson[1].

The energy spectra for the smallest three ω-values also indicate the existence of an energy-level at 2·2 MeV. The relative intensities of the neutron groups change with the angle ω.

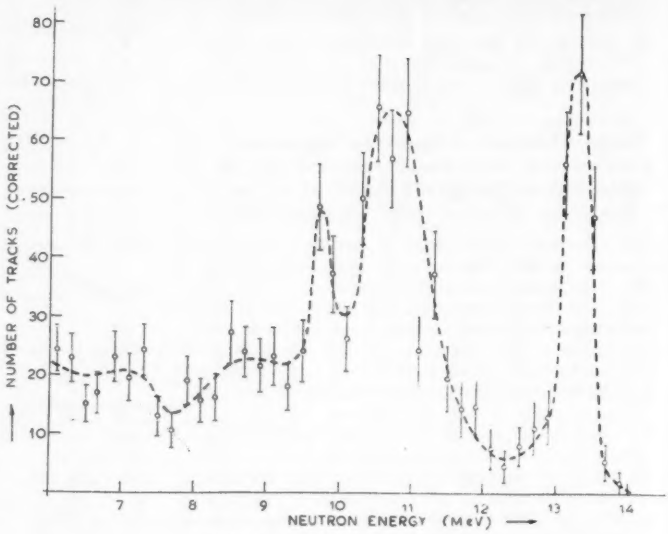

Fig. 1. 140° neutron spectrum

The angular distribution in the centre-of-mass system of the neutrons corresponding to the ground-state and the 2·9-MeV. excited state of beryllium-8 is given in Tables 1 and 2 and Figs. 2 and 3 respectively, the values in both cases being normalized to 1·00 for $\omega = 0°$.

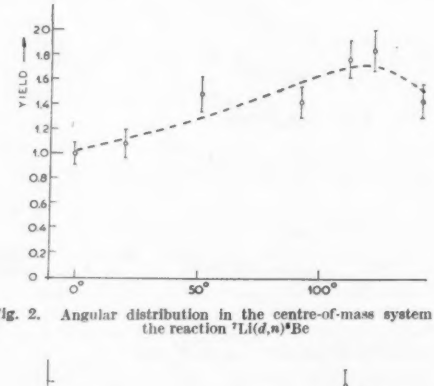

Fig. 2. Angular distribution in the centre-of-mass system of the reaction ^{7}Li(*d*,*n*)^{8}Be

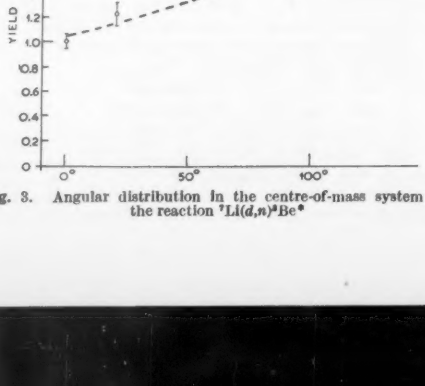

Fig. 3. Angular distribution in the centre-of-mass system of the reaction ^{7}Li(*d*,*n*)^{8}Be*

Table 1 Ground state	
0°	1·00 ± 0·09
20·7°	1·08 ± 0·12
51·5°	1·48 ± 0·14
92·0°	1·42 ± 0·12
111·9°	1·76 ± 0·15
121·7°	1·83 ± 0·14
141·3°	1·43 ± 0·13

Table 2 2·9-MeV. excited state	
0°	1·00 ± 0·06
20·7°	1·22 ± 0·09
51·5°	1·49 ± 0·10
92·0°	1·47 ± 0·09
111·9°	2·16 ± 0·13
121·7°	1·96 ± 0·11
141·3°	1·70 ± 0·10

No theory for the angular distribution of the neutrons from (d,n)-reactions has so far been worked out for low deuteron energies. The Butler theory[2] of a stripping process, originally worked out for deuteron energies between 7 and 15 MeV., has since been extrapolated to lower energies[3].

On the basis of this theory and the angular distribution curves in Figs. 2 and 3, we may conclude that both the stripping process and the compound nucleus formation are operative at the d-energy used in our experiment[4].

B Trumpy
T. Grotdal
A. Graue

Physical Institute,
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Growth Spirals originating from Screw Dislocations on Electrolytically Produced Titanium Crystals

According to the theory of Burton, Cabrera and Frank[1], crystals can only grow at supersaturations too low for two-dimensional nucleation, when dislocations are present. Where a screw dislocation terminates in a crystal face, an exposed edge is formed which, while growing, will persist and develop as a 'growth spiral' centred on the dislocation. This theory has been applied to the electrolytic production of titanium crystals.

In the course of work on the production of titanium by electrolysis of fused salt, we have obtained a number of large titanium flakes which are single crystals as revealed by X-ray examination. These hexagonal flakes have, in the main, flat (0001) basal plane surfaces. On further examination using a metallographic microscope and employing the techniques described by Griffin[2], growth spirals originating from screw dislocations have been observed on these surfaces. This is the third reported instance where direct visual evidence of screw dislocations has been obtained on metal crystals and is the first case of screw dislocations being responsible for crystal growth in electrolysis.

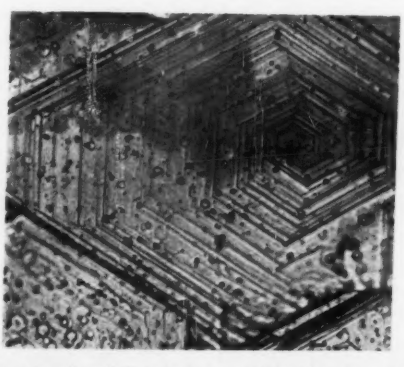

Fig. 1. Growth spiral centred on a dislocation in a single crystal of titanium. (0001 plane). vertical illumination. × 200

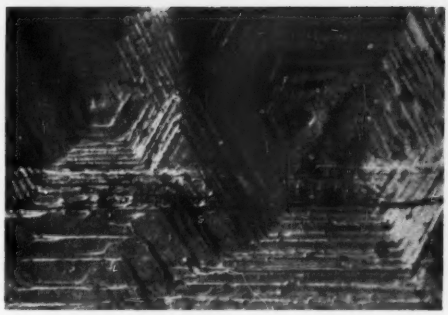

Fig. 2. Growth spirals of the opposite hand joining to form closed loops. 'In focus' technique (ref. 1). × 200. (Note mechanical twin through growth layers)

The first visual proof for the presence of dislocations in metals was obtained by Amelinckx *et al.*[3], when growth spirals originating from screw dislocations were observed on the (111) faces of gold crystals obtained by precipitation. Triangular and hexagonal growth spirals were observed and step-heights of the order of 400 ± 100 A. were measured.

More recently, Forty[4] has observed spiral growths originating from screw dislocations on the (0001) surfaces of magnesium crystals obtained in the form of thin hexagonal flakes by sublimation. The growth layers were estimated to be either one or two atoms in thickness. (The step-heights were less than 20 A.)

Growth spirals centring on multiple dislocations have been observed on our titanium single crystals (Fig. 1). The average step-height, measured by multiple-beam interference fringes of the Fizeau type, obtained with parallel, monochromatic light at normal incidence, was 240 ± 100 A. Some difficulty was experienced in making the measurements due to surface irregularities, and a technique similar to the one recently described by Tolansky and Omar[5] was used.

It is evident that most of these spirals cannot be due to dislocations of unit strength ($1/2\ d_{(0001)}$ = 2·37 A.) but are generated by groups of dislocations all having the same sign and having a resultant Burgers vector with a component normal to (0001) of approximately 100 A. However, in some cases, no deviation of the fringe system could be seen, showing that the steps are less than 100 A.

Besides multiple spirals originating at the same dislocation centres, spirals of opposite sign, interacting so as to form closed loops, have been observed, in accordance with theory (Fig. 2).

In several cases, after the first few turns of these growth spirals, they became hexagonal in form, following the hexagonal outline of the crystal and denoting the strong influence of the crystal orientation on the radial growth velocity of the titanium crystals.

One other observation that should be mentioned is the following. Some crystals have been obtained which are series of built-up hexagons of which the edges $(10\bar{1}0)$ show growth lamellæ of the type observed on zinc and cadmium deposited from vapour by Straumanis[6]. These layers are about 3000 A. in thickness on our electrolytically produced titanium and are not to be confused with the growth spirals

observed in the centres of the (0001) faces of these crystals. When these layers are complete over the length of the crystal edge, the hexagonal type of growth spirals is obtained as shown in Figs. 1 and 2.

A complete description of the observations and techniques used will be reported elsewhere.

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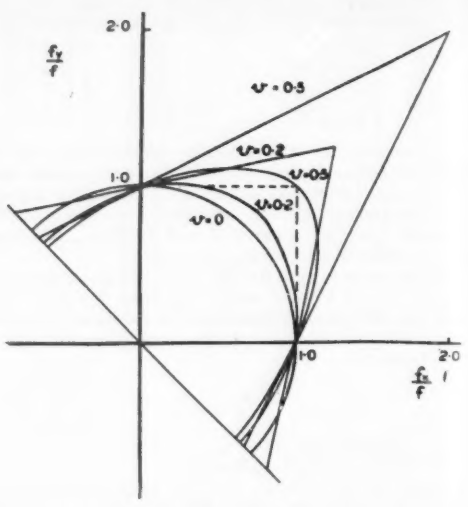
Mechanism of Fracture of Concrete

H. J. Cowan's[1] hypotheses for the fracture of concrete are very similar to those already proposed by Prof. M. Roš[2]. Such hypotheses usually rely mainly on the observations of failing loads of specimens for their justification, and proceed from the assumption that concrete may be regarded as a homogeneous isotropic material. In the Division of Building Research of the Commonwealth Scientific and Industrial Research Organization, an extensive experimental study has been made of the strain distribution in various types of concrete specimen, using one concrete mix throughout. The results suggest that in all specimens the first failures occur when the tensile strain is about 10^{-4}. In compression tests of cylinders, this strain occurs when the load is about fifty per cent of the ultimate, and in unreinforced flexural specimens at about ninety per cent of the ultimate. The measurements made here also show how widely the concrete strains may vary in a region in which they are theoretically uniform.

These results concerning maximum tensile strain and the development of tensile cracks in specimens before the maximum load is reached are confirmed by other workers[3-5]. Our tests suggest that a noticeable decrease in the gradient of the compressive stress-strain curve coincides with the formation of tensile cracks on the circumference of a cylindrical compression specimen. I believe that the so-called shear failure is a secondary development which occurs after the vertical splitting has begun. It may be of interest to note that Wästlund[6] claims to have shown that the plane of so-called shear failure in compression specimens is actually a plane perpendicular to the maximum tensile stresses.

In the accompanying graph the ratio of the stress at fracture to the uniaxial tensile strength is plotted for various hypotheses of failure for a range of stresses from $f_x = -f_y$ to $f_y = -f_x$. The hypotheses chosen are maximum normal stress (straight broken lines), maximum normal strain (straight full lines) and maximum total strain energy per unit volume (curved full lines). It is desired to show the extent to which the limit provided by each hypothesis may vary according to the value assumed for Poisson's ratio. In this graph the extremes for $\nu = 0$ and $\nu = 0{\cdot}5$ are shown (the maximum strain theory with $\nu = 0$ coincides with the maximum stress theory). These are undoubtedly extremes, but such values have been proposed for concrete under certain conditions[4,7].



Since Poisson's ratio itself may vary widely for one mix, and in the range of values most commonly accepted ($0{\cdot}1 < \nu < 0{\cdot}25$) the limiting curves for all hypotheses lie close together, the difficulty of choosing any one hypothesis, principally on an observation of the loads and hence the stresses, during the test becomes obvious. A complete set of strain measurements for the effective part of the test specimen is also essential.

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Enhancement of Auroral Hydrogen Lines towards Lower Latitudes

Many years ago, I suggested that the bundles of solar electric rays which produce the auroræ and most magnetic disturbances are composed of electrons electrostatically neutralized by positive ions of great specific charge, mainly protons[1-4].

On this view the current density (i) of a bundle composed of electrons and protons is given by

$$i = ne\,(V_e - V_p), \qquad (1)$$

where n is the number of electrons or protons in unit volume, and V_e and V_p are the velocities of the electrons and protons respectively.

The number of electrons ν_e and protons ν_p entering unit cross-section perpendicular to the direction of the current in unit time is $\nu_e = nV_e$, and $\nu_p = nV_p$. Thus the velocity of the protons (V_p) relative to that of the electrons (V_e) essentially determines the relative intensity of the hydrogen lines in the auroral luminescence.

A bundle constituted in this way, being magnetically active, produces the magnetic fields responsible for the magnetic perturbations, and at the same time it is deviated in the earth's magnetic field.

In a magnetic field of intensity F, each unit volume is acted on by a force K given by the equation:

$$K = F.en\,(V_e - V_p)\sin\varphi, \qquad (2)$$

where φ is the angle between F and the direction of the current density in the point, and K is perpendicular to the vectors F and i.

The correctness of this view regarding the constitution of the solar ray bundles was proved when, in the years 1939–41, it was found that hydrogen lines occasionally appeared with considerable intensity in the auroral luminescence, and that they showed a pronounced Doppler displacement corresponding to velocities of the order of 10^8 cm./sec. [5–9].

Thus the proton velocities may vary from very small values corresponding to extremely small intensities of the hydrogen lines to values at least up to 2,000–3,000 km./sec., while the electrons have velocities of the order of 10^{10} cm./sec., and are thus mainly responsible for the magnetic activity of the bundle.

On account of their much greater mass, the protons may have a dominating influence on the magnetic deviability of the bundle. It is easily shown that for proton velocities greater than about 10^7 cm./sec.. the radius of curvature of the protons will be greater than that of the electrons, provided electrons and protons could move independently of each other.

Thus the increase of proton velocities, which means greater intensity of the hydrogen lines, will increase the magnetic stiffness of the bundle, with the result that the auroræ are driven away from the magnetic axis point and towards lower latitudes. Consequently, we should expect that the relative intensity of the auroral hydrogen lines, for a certain magnetic meridian, would increase with magnetic polar distance or towards lower latitudes.

Since the auroral hydrogen lines and their Doppler displacement were detected about twelve years ago, a considerable number of strongly exposed auroral spectrograms have been obtained both at Tromsoe and Oslo. The intensities of the Hβ-lines were found relative to the negative nitrogen band 4709 and expressed by the ratio $I_{(H\beta)}/I_{(4709)}$ [10].

At Oslo we obtained twelve, and at Tromsoe eleven, spectrograms showing a quite strong band at 4709.

The mean values of the ratio $I_{(H\beta)}/I_{(4709)}$ derived from these spectrograms were: Oslo, 1·01; and Tromsoe, 0·15.

Thus the observational results, so far as they go, show a considerable increase of the relative intensity of the auroral hydrogen lines towards lower latitudes, in agreement with the consequences drawn from the proposed constitution of the solar ray bundles.

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A Microwave Vibration Wattmeter

It has been shown[1] that mechanical forces exerted by an electromagnetic field can be employed to make absolute measurements of microwave power at levels of a few watts or more. Experiments carried out in this department by Mr. I. M. Stephenson have shown that the same method can be used to measure a few tens of milliwatts of power at a wave-length of 3·2 cm. by making use of a vibration-free table and amplifying the resulting small deflexion by means of a photo-cell and galvanometer.

However, the apparatus is rather inconvenient in use, and it is the purpose of this communication to describe a new principle which greatly increases the sensitivity. Mechanical resonance is used to increase the deflexion obtainable, but at the same time electrical resonance is employed in an unusual way. The power to be measured passes along a wave-guide terminated by a high-Q cavity. A short horizontal dipole is suspended by its mid-point by a quartz fibre inside the cavity, and tends to align itself parallel with the unperturbed electric field. When the dipole makes an angle of 45° with this direction, the cavity is resonant at the frequency at which power is to be measured, and is matched to the input wave-guide. It is arranged that a very small change in this angle detunes the cavity completely.

Consider the dipole at rest in the 45° position. Suppose microwave power is admitted to the cavity by means of a wave-guide switch. The dipole will experience a torque, tending to turn it clockwise, say. A very small clockwise rotation will suffice to reduce the torque to a negligible amount, but the dipole has then acquired some angular momentum, and it will continue its clockwise swing to an angular position $45° + \theta_1$ determined by the restoring force of the fibre and frictional forces. When this limit is reached, the oscillator is switched off, and the dipole swings anticlockwise to an angle which, if the frictional forces are small, is almost equal to $45° - \theta_1$. If the oscillator is switched on again, the dipole again experiences a torque as it passes through 45°. This time it swings to a new limiting position $45° + \theta_2$, θ_2 being greater than θ_1, and the cycle of events is repeated until a constant amplitude of mechanical oscillation is reached, from $45° + \theta_0$ to approximately $45° - \theta_0$. It can be shown that the angle θ_0 is given by:

$$\theta_0^2 = \frac{P}{2f} \cdot \frac{M}{c}$$

In this formula P is the power delivered to the cavity at resonance, f is the frequency, c is the specific couple of the quartz fibre, and M is the 'mechanical magnification' defined as the ratio of the initial amplitude to the decrease in amplitude per period for natural oscillations.

The remarkable feature of this result is that it is independent of the Q-factor of the cavity and of the characteristics of the dipole. This is because the increase in torque at resonance which arises from an increase in Q-factor or length of dipole is exactly compensated by the reduction in the time during which the cavity stays in tune, so that the *impulse* received is unchanged. Because of this independence, the method is particularly attractive at millimetre wave-lengths, when accurate measurements of Q-factor, etc., are not very readily accomplished.

Another feature of importance is that θ_0 is proportional to $\sqrt{(P/f)}$, whereas in the instrument described previously[1] the deflexion is proportional to P/f. It follows that the new method has the advantage that the deflexion falls off less rapidly with decreasing power and increasing frequency. However, the formula quoted above is only valid when the angular rotation of the dipole required to detune the cavity to $1/\sqrt{2}$ of the amplitude at resonance is small in comparison with θ_0. If this condition is not met, a correction including the Q-factor must be introduced.

Preliminary experiments at a wave-length of 3·2 cm. show that an adequate deflexion ($\sim$ 30 cm. at 1 metre) can be obtained easily with a power of 100 mW. or less.

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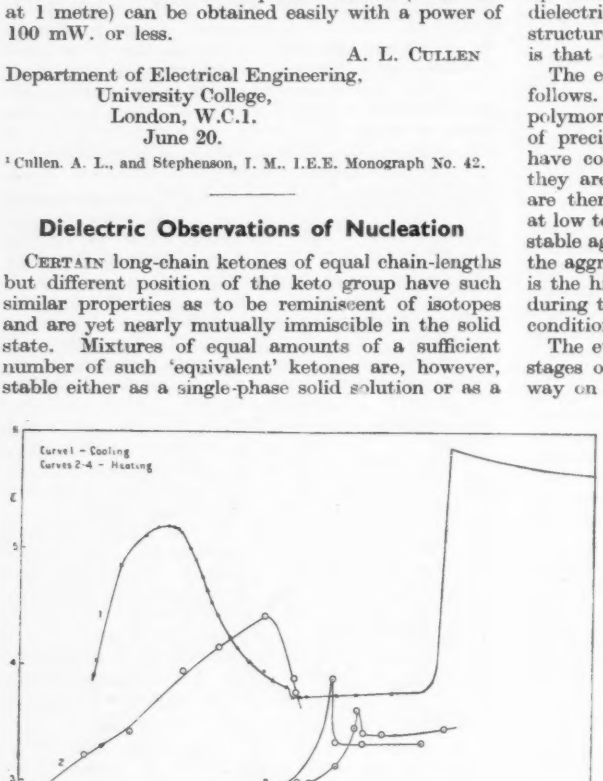
Dielectric Observations of Nucleation

Certain long-chain ketones of equal chain-lengths but different position of the keto group have such similar properties as to be reminiscent of isotopes and are yet nearly mutually immiscible in the solid state. Mixtures of equal amounts of a sufficient number of such 'equivalent' ketones are, however, stable either as a single-phase solid solution or as a multiphase mixture of the constituents[1]. Mixtures of this kind are exceptionally suitable for a study of precipitation, since all constituents are precipitated simultaneously. Recent measurements of dielectric properties carried out during the precipitation of such a mixture yield information on early stages of nucleation and on the dielectric properties of small aggregates.



Dielectric constant of a mixture of five ketones in the course of precipitation

The mixture investigated consisted of equal amounts of five equivalent ketones of the formula $C_mH_{2m+1}.CO.C_{17-m}H_{35-2m}$, with m equal to 3, 4, 5, 6 and 7. The multiphase form of the mixture is stable up to the melting point at 27·5° C., but the metastable single-phase form, which shows a polymorphic transition at 13·5–15·5° C., can be preserved indefinitely above the temperature of this transition. On cooling below this temperature, complicated phenomena occur in the mixture which find expression in its dielectric properties.

The accompanying graph shows the dielectric constant of the mixture at 800 c./s., during different heat-treatments. Curve 1 was obtained during cooling of the specimen, while curves 2, 3 and 4 were obtained on heating after the specimen had been annealed for varying times at temperatures below 4° C. The longer the time of annealing, the smaller is the peak observed and the higher the temperature at which it occurs. Specimens annealed for some weeks retain their low dielectric constant up to the melting point, and their structure, as indicated by X-ray powder photographs, is that of the multiphase form.

The experimental evidence may be interpreted as follows. On cooling below the temperature of the polymorphic transition the mixture becomes capable of precipitation, and aggregates are formed which have comparatively high dielectric constants while they are small and/or imperfect. These aggregates are thermodynamically unstable, and on annealing at low temperatures they change gradually into more stable aggregates of lower permittivity. On reheating, the aggregates are dissolved, at a temperature which is the higher the more stable they have grown, and during their dissolution they pass again through the condition connected with high dielectric constants.

The evidence indicates a sequence of intermediate stages of precipitation, depending in a complicated way on time and temperature. In this respect the mixed ketones are analogous to age-hardening alloys[2], and their study might be of interest to metallurgists. Compared with alloys, the ketones offer two advantages for the investigation of precipitation: precipitating aggregates form the bulk of the material and are not dispersed in a matrix, and their properties can be studied by very sensitive dielectric methods.

The comparatively high permittivity of the precipitating aggregates is of interest from the point of view of dielectrics: even though the permittivity of the solid mixture remains below that of the liquid, the evidence indicates a possibility of obtaining high dielectric constants with some kinds of small or imperfect aggregates. The relaxation times of dipoles in such aggregates are also of interest. From the points of view of the theories either of phase changes in solids or of dielectrics, it would obviously be interesting to correlate the physical properties of the precipitating aggregates with their structure. Work on this is in progress.

We wish to thank Mr. C. G. Garton for many helpful discussions and the Director of the Electrical Research Association for permission to publish this communication.

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A Superstructure in Spinels

In 1935, E. Kordes[1] recognized that $LiAl_5O_8$ has nearly a spinel structure, but he observed a large number of extra lines, which he could not explain. A. Hoffman[2] prepared the corresponding compound $LiFe_5O_8$, which again was recognized as having nearly spinel structure. We found[3] that the powder diagrams of $LiFe_5O_8$ correspond with a primitive cubic lattice with a lattice constant of 8·33 A. The space group was found to be very probably $P4_332$ (or $P4_132$) and the positions of the atoms (in the notation of the International Tables, 1935) are:

$P4_332$ 4 Li at 4 (6)
12 Fe „ 12 (*d*) with $x = \frac{5}{8} + \Delta_1$
8 Fe „ 8 (*c*) „ $x = 0 + \Delta_2$
24 O „ 24 (*e*) „ $x = \frac{1}{8} + \Delta_3$, $y = \frac{1}{8} - \Delta_4$, $z = \frac{1}{8} + \Delta_5$
8 O „ 8 (*c*) „ $x = \frac{3}{8} + \Delta_6$

with Δ_2, Δ_4, Δ_5 and Δ_6 approximately 0·007 and Δ_1 and Δ_3 still smaller.

For all Δ's equal to 0, this would mean an ideal spinel lattice with an ordered arrangement of lithium and iron ions in the ratio 1 : 3 over the octahedral sites. The type of the order is best described by considering only the sixteen octahedral interstices. These are occupied by four lithium and twelve iron ions in such a way that each lithium ion is surrounded by six iron ions in an octahedron elongated along a trigonal axis and each iron ion by four iron and two lithium ions.

Single crystals of $LiFe_5O_8$ have been grown and investigated and the above deductions are fully confirmed.

Below 735° C. the four lithium ions are distributed in this ordered way over the sixteen octahedral interstices. The long-range order decreases only very slowly up to this temperature. Above 755° C. the long-range order has completely disappeared and the four lithium ions are distributed over the sixteen octahedral interstices only. Up to at least 1,000° C. they do not enter to an appreciable extent into the tetrahedral interstices.

Between 735° and 755° there exists a transition region where the equilibrium long-range order vanishes within a temperature-range of a few degrees. The transition velocity above 755° C. and below 735° C. (down to 450° C.) is very high (transition within a few seconds to a minute). Between 735° and 755° there exists a region where the transition to the equilibrium is extremely slow. By rapid quenching from 950° C. we obtained the disordered phase at room temperature.

$LiAl_5O_8$ shows the same type of superstructure, but the order–disorder transition takes place at much higher temperature. We obtained the disordered phase by quenching from 1,350° C.

Some specimens of γFe_2O_3, prepared by E. W. Gorter of this laboratory, gave very nearly the same diagrams as $LiFe_5O_8$. They proved to contain some water molecules. In these γFe_2O_3 specimens the type of ordered structure described for $LiFe_5O_8$ is present, which in the ideal case would require a ratio of 1 : 3 for the ordering elements. In the description of γFe_2O_3 as a spinel with vacancies[4], $Fe_8(Fe_{10\frac{1}{3}}\Delta_{3\frac{1}{3}})O_{32}$, the ratio of vacancies to iron ions at the octahedral interstices would be at most 1 : 5. The ratio ideal for ordering would be reached by incorporating water molecules, approaching the formula HFe_5O_8 as a limiting formula.

Recently, Houben[5] has shown by absorption measurements that the compound HAl_5O_8 also exists under certain conditions. As shown by Ervin[6], the transition from boehmite to αAl_2O_3 and goethite to αFe_2O_3 through the γ oxides can be regarded as a gradual rearrangement of the aluminium and iron ions in the cubic close-packed oxygen framework. Since the products of the first transition steps are only nearly anhydrous, the very mobile protons might be expected to play an important part in these transformations. In special cases such as the γFe_2O_3 preparations mentioned, they can even give rise to a highly ordered superstructure in the γFe_2O_3 phase, thus showing that they are not merely present as absorbed water.

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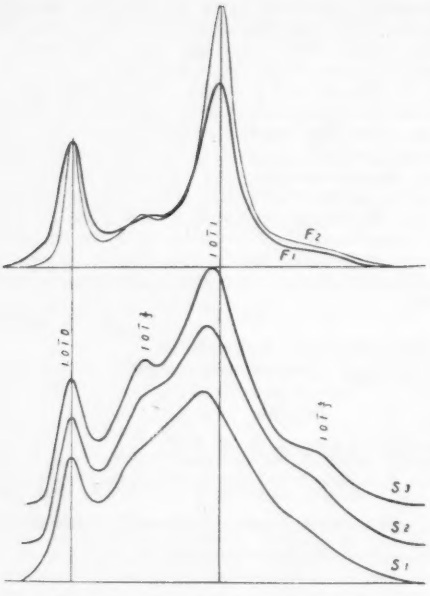
Crystal Distortion of Graphite in Cast Irons

Recently, Debye–Scherrer line-breadths, the parameters of unit cells and the proportions of α- and β-modification of graphite present in cast irons, have been published by W. S. Owen and B. G. Street[1]. In connexion with this and other work, I have investigated the variation of disordered structure within a graphite grain by removing, step by step, outer layers of the grains by an oxidizing agent, since the variation seems to exist if we consider the crystal growth of irons.

The graphite samples used were a coarse flake graphite in a commercial grey cast iron, and a temper graphite in a commercial black-heart malleable cast iron of pipe fittings. The graphites were extracted from the cast irons by dissolving with hot dilute hydrochloric acid and washing with hydrofluoric acid. Then the outer layer of the grains was dissolved by wet oxidization. Many examples are known[2] of penetration of foreign atoms between the layer planes of the graphite crystal by the action of liquid agents; this results in the increase of the lattice parameter normal to the layer planes. In the present treatment it is necessary that the oxidizing agent should attack gently and uniformly over the grain surface without destroying inner structure. For this purpose, the samples were boiled in an 8 per cent solution of potassium dichromate mixed with sulphuric acid (sp. gr., 1·29) in a flask fitted with a reflux condenser. The grain size of the powder gradually decreased as the boiling continued; after 12 hr. in the case of the flake graphite, most of the grains became hexagonal in shape or fragments of hexagons, although the initial shape was irregular and only in rare cases were hexagonal figures observed on the grain surface.

The Debye–Scherrer patterns of these specimens were obtained by using copper $K\alpha$ rays and a camera



of 20-cm. radius. The intensity distribution curves of a portion of interest in the diffraction patterns are shown in the accompanying diagram, in which the curves have been reduced to the intensity scale from the microphotometer curves by using step-sector marks, the $10\bar{1}0$ line being made of constant height. The peaks of this line are arranged so as to lie on a vertical line. Curve *F*1 (thick line) was obtained with the flake graphite before the dichromate treatment, and curve *F*2 (thin line) with the same specimen oxidized for 12 hr. (weight loss 75·6 per cent). As will be seen from the latter curve, the lines are markedly sharper and the $10\bar{1}1$ line is enhanced. Curves *S*1, *S*2 and *S*3 were obtained with the temper graphite specimens oxidized for 0 hr., 2 hr. (weight loss 32·2 per cent) and 12 hr. (weight loss 74·6 per cent) respectively. It will be seen that the breadth of the lines corresponding to the α- and β-modifications of graphite decrease successively, and the peaks of the $10\bar{1}1$ line shift towards the position for the perfect crystal as the grain-sizes decrease. In addition, the increase in intensity of the $10\bar{1}\frac{2}{3}$ and $10\bar{1}\frac{1}{3}$ lines of β-graphite is noticeable. However, further sharpening of the lines was not observed after the reduction of the grain size by further oxidization up to 24 hr. (weight loss 98·2 per cent). From these results, it can be concluded that the crystal structure is more perfect in the region of the core of the grains where the crystals were first formed. In order to examine the effect of crystal distortion which might be produced when preparing the specimen rod, a slit specimen holder with a slit width of 0·1 mm. was employed in place of the specimen rod, the powdered specimens being placed in front of the slit. X-Rays diffracted by the powder reach the photographic film after passing through the narrow slit, and hence very sharp lines are produced. With this device, a sharp 0002-line of the flake graphite was obtained, while the line broadened due to the orientation of the crystals when an extruded specimen was used. It has been confirmed that the general features of the diffraction patterns are similar to those shown in the present diagram; however, the appearance of spots on some lines of the flake graphite, due to the coarse grain, made the film inadequate for microphotometry.

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Work-hardening of Annealed Mild Steel under Static and Dynamic Conditions

It was found by Meyer[1] that when a hard ball is pressed into the surface of a metal by a force F, thus forming an impression of diameter d, the relation

$$F = kd^n \qquad (1)$$

holds, where k is a constant depending upon the metal and ball diameter and n, the Meyer index, is a constant depending only upon the metal. The Meyer index is 2·0 for metals which do not work-harden, for example, materials already fully worked, whereas for materials which do work-harden n is greater than 2·0, the greatest value being about 2·5. It has so far only been possible to examine equation (1) under conditions of static loading, but recently a method has been described for the continuous measurement of force throughout impact[2], and this has been adapted for the measurement of the index n under dynamic conditions. The force used for this purpose is the maximum force of impact, and the diameter is the diameter of the impression left after impact.

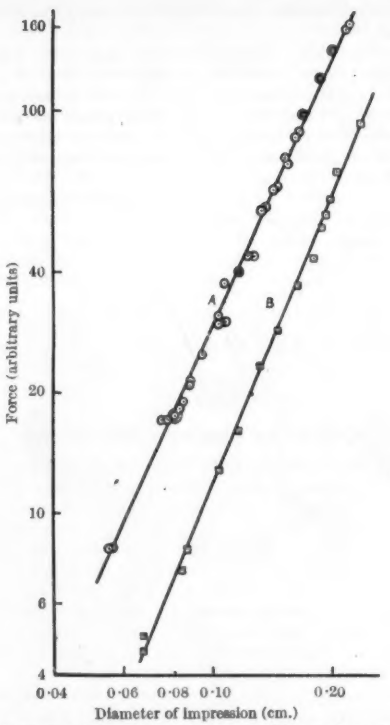
Static and dynamic measurements have been made with $\frac{1}{8}$-in. (0·32-cm.) diameter ball-bearing indenters upon the same specimen of annealed mild steel. The diameters of both sets of impressions covered the same range, the smallest diameter being greater than 0·1 of the ball diameter, ensuring that all the measurements are in the fully plastic regime. In dynamic tests the maximum force was reached in about 300 μsec., and in static tests the maximum force was maintained for one minute.

The accompanying graph shows log–log plots of the forces as functions of the diameters of the impressions. In each case the points fall near straight lines, the slopes being the indices. The dynamic slope ($2{\cdot}20 \pm 0{\cdot}04$) is less than the static slope ($2{\cdot}39 \pm 0{\cdot}05$). The t test shows that the probability of this (0·19) or a greater apparent difference arising by chance is less than 0·1 per cent; the result is highly significant. The interpretation offered is that a lesser degree of work-hardening occurs under dynamic conditions than in static tests.

It is particularly important to check this interpretation, as workers with some materials have recently questioned the value of the Meyer index as a guide to work-hardening[3]. It might be expected from equation (1) that the ratio of the Vickers hardnesses (H_2/H_1) of the materials at the centres of static impressions of diameters d_2 and d_1 should be given approximately by

$$\log (H_2/H_1) = (n - 2) \log (d_2/d_1). \qquad (2)$$

This has been tested; an experimental value of the ratio was 1·43, and the calculated value 1·59. This confirms that in static tests with annealed mild steel,



The forces as functions of the diameters of impressions made in (*A*) impacts, (*B*) static tests. (The relative position of (*A*) to (*B*) is arbitrary in the vertical direction)

the work-hardening predicted by equation (1) does, in fact, occur. A further check has been made. The static and dynamic indices of the same specimens were measured after the specimens had been cold-worked by compressing them to half their original thickness. It is to be expected with fully worked material that both static and dynamic indices should be 2·0; the values found were 2·08 ± 0·04 for the static index and 2·09 ± 0·03 for the dynamic index. This observed equality of the indices also shows that the earlier observed difference was not simply due to instrumental effects.

It therefore appears that in impact the deformed material is not work-hardened to the same extent as in a static test. This difference might be permanent or temporary. If permanent, the difference between the indices leads to the expectation that, for impressions of diameter 0·22 cm., the Vickers hardness at the centres of those formed in impact should be about 20 per cent less than the corresponding hardness of static impressions. Forty impressions of 0·22 cm. diameter were formed statically in the annealed material and forty dynamically. The mean hardness at the centres of static impressions was 164 ± 2 kgm. mm.$^{-2}$, and at the centres of dynamic impressions, 166 ± 2 kgm. mm.$^{-2}$. (The mean hardness of the undeformed material from forty tests was 95 ± 1 kgm. mm.$^{-2}$.) Therefore, it is concluded that the lesser degree of work-hardening which occurs in impact is temporary, the mild steel changing after the impact to the same state as exists after a static test. Other materials are being examined and already similar effects have been found.

I gratefully acknowledge the help of Mr. B. Jones, who has made many of the measurements.

(All the limits quoted above are ± twice the appropriate standard errors.)

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Angular Momentum in Dirac's New Electrodynamics

Tyabji[1] recently determined the canonical and symmetrical energy momentum tensors of Dirac's[2] new theory of electrodynamics. Tyabji used the conventional definition of the canonical energy momentum tensor and symmetrized this tensor in the traditional manner[3-5]. The canonical tensor

$$T_{\rho\sigma} = \frac{\partial(kv_\lambda)}{\partial x_\sigma} F_{\rho\lambda} + \frac{\partial\xi}{\partial x_\sigma} F_{\rho\mu} \frac{\partial\eta}{\partial x_\mu} + \frac{\partial\eta}{\partial x_\sigma} F_{\mu\rho} \frac{\partial\xi}{\partial x_\mu} + \delta_{\rho\sigma} L \tag{1}$$

given by Tyabji can be written without the explicit appearance of the ξ and η variables, as follows:

$$T_{\rho\sigma} = F_{\rho\mu}F_{\sigma\mu} + F_{\rho\mu} \frac{\partial k v_\sigma}{\partial x_\mu} + \delta_{\rho\sigma} L; \tag{2}$$

or

$$T_{\rho\sigma} = F_{\rho\mu}F_{\sigma\mu} - \lambda v_\sigma v_\rho + \delta_{\rho\sigma} L + \frac{\partial}{\partial x_\mu} (k v_\sigma F_{\rho\mu}). \tag{3}$$

The symmetrizing tensor[1] $T'_{\rho\sigma} = \frac{\partial G_{\mu\rho\sigma}}{\partial x_\mu}$, is

$$T'_{\rho\sigma} = - \frac{\partial}{\partial x_\mu} (k v_\sigma F_{\rho\mu}) \tag{4}$$

or

$$T'_{\rho\sigma} = - \lambda v_\sigma v_\rho - F_{\rho\mu} \frac{\partial k v_\sigma}{\partial x_\mu}. \tag{5}$$

(5) simply removes the unsymmetrical mixed term of (2) and adds the 'matter' contribution to the energy momentum tensor to yield[1]

$$\theta_{\rho\sigma} = T_{\rho\sigma} + T'_{\rho\sigma} = F_{\rho\mu}F_{\sigma\mu} - \lambda v_\sigma v_\rho + \delta_{\rho\sigma} L. \tag{6}$$

If (3) is added to (4), the canonical tensor contains the 'matter' term, and the symmetrizing tensor cancels the mixed last term of (3). λ is a scalar function of x_μ, and can be interpreted as the rest mass density of the streams of electrical charge.

The conservation of energy and momentum is ensured by the vanishing divergence of (6). The divergence of (6) can be written

$$\frac{\partial\theta_{\rho\sigma}}{\partial x_\rho} = \frac{\lambda}{k} \left(v_\rho F_{\rho\sigma} - k v_\rho \frac{\partial v_\sigma}{\partial x_\rho} \right), \tag{7}$$

and vanishes by virtue of Lorentz's equation

$$v_\rho F_{\rho\sigma} = k v_\rho \frac{\partial v_\sigma}{\partial x_\rho} = k \frac{dv_\sigma}{ds}, \tag{8}$$

which is a consequence of the Dirac theory.

The angular momentum, based on $\theta_{\rho\sigma}$, is equal to the sum of the 'field' angular momentum and the 'matter' angular momentum. Angular momentum

is conserved, because $\theta_{\rho\sigma}$ is symmetrical and divergence free. In the usual classical formulation of the Maxwell field, the angular momentum is automatically resolved into orbital and spin components[4]. This decomposition is not justifiable on physical grounds, and, in addition, it is not gauge invariant. If one associates a spin density with $G_{omn} - G_{onm}$, customary Maxwell theory yields the non-gauge invariant $E_m A_n - E_n A_m$, whereas Dirac's theory yields $E_m k v_n - E_n k v_m$. In space-time regions where there is electric charge, the latter expression seems to be unique. For space-time regions where there is no charge, the Dirac spin density, in the Lagrangian formulation of his theory, seems to be indeterminate, because v_μ is indeterminate[5].

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The Energy Momentum Tensor in Dirac's New Electromagnetic Theory

Tyabji[1] has shown that the energy momentum tensor in the vortical form of Dirac's new electromagnetic theory[2] has the same form as that belonging to the non-vortical theory. The method he uses of first obtaining a non-symmetrical form and then adding a suitable symmetrizing term depends on the particular definition of the electromagnetic potential A_μ and thus does not show why the two energy momentum tensors should have the same form.

The energy momentum tensor can be obtained by a different method, namely, by writing the metrical tensor $g_{\mu\nu}$ explicitly in the Lagrangian function L and then considering the variation of the integral $\int L \sqrt{-g}\ dx^1 dx^2 dx^3 dx^4$ with respect to $g_{\mu\nu}$.

In the non-vortical form of Dirac's theory, one has :

$$L = -\tfrac{1}{4} g^{\mu\sigma} g^{\nu\tau} F_{\sigma\tau} F_{\mu\nu} + \tfrac{1}{2}\lambda(g^{\mu\nu} A_\mu A_\nu - k^2), \quad (1)$$

and in the vortical form :

$$L = -\tfrac{1}{4} g^{\mu\sigma} g^{\nu\tau} F_{\sigma\tau} F_{\mu\nu} + \tfrac{1}{2}\lambda'(g^{\mu\nu} v_\mu v_\nu - 1), \quad (2)$$

where

$$v_\mu = k^{-1}\left(A_\mu - \xi \frac{\partial \eta}{\partial x^\mu}\right) \quad (3)$$

and

$$\lambda' = k^2 \lambda. \quad (4)$$

While a velocity vector is usually regarded as contravariant, the v_μ defined in Dirac's vortical theory is initially covariant, so that v_μ is independent of $g_{\mu\nu}$ and $v^\mu = g^{\mu\nu} v_\nu$. For this reason the covariant v_μ is used in (2). Variation with respect to $g_{\mu\nu}$ gives directly the symmetrical form of the energy momentum tensor obtained by Tyabji. Since the velocity vector in the non-vortical theory is defined by $v_\mu = k^{-1} A_\mu$, and since (1) and (2) contain $g_{\mu\nu}$ in the same way, it is clear that the resulting energy momentum tensors will have the same form, despite the different definitions of the electromagnetic potentials in the non-vortical and the vortical theories. Since the variables ξ, η do not enter (2) explicitly, they do not appear explicitly in the energy momentum tensor.

I take this opportunity to mention that the Schrödinger form of the non-vortical theory[3] is contained in the similarity theory of relativity, the variational principle being constructed in terms of the curvature scalar of a general symmetrical similarity tensor $S_{\sigma\tau}$. The details will shortly appear in *Physical Review*.

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Colour in Electron Microscopy

The wave-length of the beam of an electron microscope, compared with visible light, is the property akin to colour. The beam is 'monochromatic' and it is standard practice to maintain it so within very narrow limits. The wave-length for electrons, in terms of their velocity expressed in electron volts, is given by the equation $\lambda = \sqrt{(150/V)}$ Angstrom units, where λ is the wave-length and V is the voltage accelerating the electrons. The 'colour' (wave-length) of the electron beam is varied by varying the voltage accelerating the electrons.

The image produced by the electron microscope is somewhat similar to a radiograph. The light and shade depend on the difference in the scattering and absorption of the beam by different parts of the specimen, which in turn depend on the wave-length. This is a function of the accelerating voltage, the thickness of the specimen, and the atomic numbers of the atoms composing the specimen.

The electron micrographs of the same specimen taken with electron beams of 25 kV. and 75 kV., respectively, show different detail and a certain amount of overlap. The internal detail in the higher-voltage picture shows up very well ; but very little is seen in the lower-voltage picture (see Figs. 1 and 2). The contrast of some low-density detail outside the bacteria which can be distinguished in the lower-voltage micrograph is reduced to such an extent as to render it nearly invisible in the higher-voltage picture. The similarity between micrographs taken at various voltages and X-ray pictures taken at various voltages, which is the basis of colour radiography introduced by Donovan[1,2], is obvious.

Colour electron microscopy involves the use of electron beams of two or more different voltages, and produces images in which colour is used to differentiate structure. Electron micrographs of the specimen are taken at two or more voltages (wave-lengths) selected to give the desired contrast. The images thus produced are each tagged in a visible colour such as red, green and blue, for a set of three electron micrographs, and are combined by optical superimposition or other means to form a colour electron micrograph. Such a composite colour picture shows not only variations in density but also variations in colour. Different colours in the final micrograph represent varying distribution of materials in the specimen absorbing or scattering at one or another of the wave-lengths (voltages) selected. In

simplified effect, this method attempts to translate them into visible colours such as are seen in stained material used in light microscopy.

The easiest procedure is to treat the two or more electron micrographs taken at different voltages (wave-lengths) as separation negatives are in colour photography. A composite colour micrograph is assembled instantaneously by projecting in register the electron micrographs on to a viewing screen through suitable colour filters, or by means of viewing devices such as the chromoscope or 'Kromskop'. Permanent colour composite electron micrographic prints can be made with a modification of the 'Trichrome Carbro' process. Colour transparencies are made by photographing, serially and in register, the electron micrographs taken at the various voltages through appropriate colour filters on to the same frame of a colour photographic film.

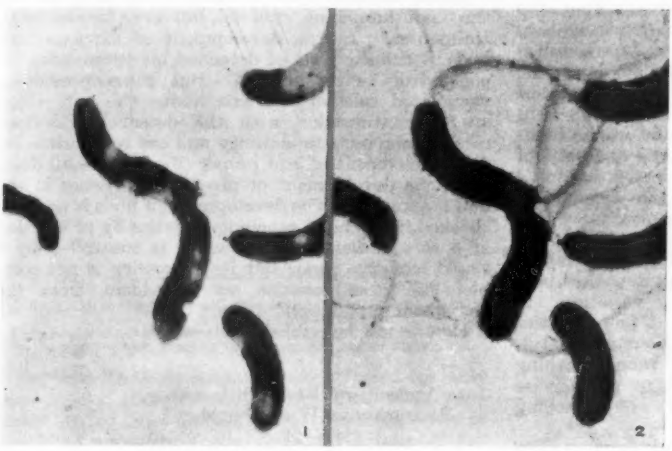

Fig. 1. Electron micrograph taken at 75 kV. Internal detail shows up, but external detail is practically invisible

Fig. 2. Electron micrograph taken at 25 kV. of same specimen as Fig. 1. Internal detail shows up poorly, but external detail, such as flagella, shows up well

Satisfactory results can be obtained by using two voltages and two colours

Shadow-casting techniques are very popular in electron microscopy; they give a three-dimensional effect. The great defect of shadow casting is that only an outline of the organism shows and no internal structure is apparent. The electron microscope is capable, however, of showing great depth of focus and internal structure. A pseudo depth effect can be produced by careful choice of colours; red stands out, blue is recessive. This, allied to true stereoscopic electron microscopy, should produce very satisfactory stereoscopic electron micrographs.

We wish to thank Dr. F. T. Perkins and Dr. N. W. Preston, of the Department of Bacteriology, University of Manchester, and Messrs. Metropolitan-Vickers, Ltd., for their help.

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A Genetical System admitting of Two Stable Equilibria

It has long been known that, in a population where different genotypes possess different selective advantages, it is possible for balanced polymorphism to exist. That is to say, there is an equilibrium between the proportions of different genotypes which is stable under random mating with differential viability and fertility. I do not know, however, whether any case has been recognized in Nature, or discussed theoretically, in which it is possible for two distinct non-trivial stable equilibria to exist. (A trivial equilibrium is an extreme case when, for example, some genes or genotypes are unrepresented in the population, and is of little interest.) It may therefore be of some theoretical value to construct a genetical system admitting of two distinct stable states of balanced polymorphism.

Analogy with electrical and mechanical oscillating systems suggests that the necessary degree of complexity may be achieved by a system composed of two 'coupled' sub-systems, possessing sufficiently unlike properties. Now the random mating of the sexes can be regarded as an interaction between two sub-populations. It is therefore natural to inquire whether a population in which the same genotypes have different viabilities in the two sexes is one admitting of a multiplicity of distinct equilibria. This expectation is verified. It is easy to specify a theoretical population involving three genotypes AA, Aa and aa with selective advantages different within and between sexes, which has three equilibria, of which two are stable and the third unstable. For example, with the scheme of viabilities:

	AA	Aa	aa
Females	0·50	1·00	0·50
Males	2·15	1·00	2·15

we obtain three equilibria characterized as follows for gene ratios in the two sexes and for stability:

Gene ratio (A : a)

Equilibrium state	In females	In males	Character
I	0·582	0·339	Stable
II	1·000	1·000	Unstable
III	1·718	2·951	Stable

I will give elsewhere a brief discussion of systems of this type. It is shown that they may possess (*a*) no non-trivial equilibrium state; or (*b*) a unique non-trivial equilibrium which may or may not be stable; or (*c*) three non-trivial equilibria, of which as many as two may be stable, the third being unstable.

All the possibilities relating to the case of three equilibria, and the necessary conditions on the viabilities, have not been exhaustively explored numerically, but their complete examination would present no great difficulty. The analysis suggests that a necessary condition for the existence of three

equilibria is that, in at least one sex, at least one homozygote must be at an advantage relative to the heterozygote. It suggests further that the difference in viability between homozygotes and the heterozygote is required to be in opposite senses in the two sexes.

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Origin and Development of Axillary Buds in Jute (*Corchorus capsularis*)

Branching characteristics of the vast majority of plants are not a desirable character in a fibre crop like jute. Some foreign varieties of *Corchorus capsularis* like Halmahera, Jap Red and Jap G, unlike the Indian varieties, do not usually branch, as the axillary buds are normally absent in the axils of the leaves. These varieties supply the gene for non-branching character to be incorporated in the high-yielding Indian varieties. Though the anatomy of normal jute plant has been investigated in detail by Kundu[1,2], the organization of the shoot apex in the non-branching plants requires study, to find whether the absence of axillary buds is merely due to dormancy or complete absence of bud meristem in the axils of leaves. Such a study will doubtless help in rigid selection for non-branching varieties. A comparative developmental anatomy of four varieties of *Corchorus capsularis*, *D*154 (a branching variety), Halmahera, Jap Red and Jap G (non-branching varieties), was taken up in order to get precise information about the nature of non-branching character.

In the branching variety, *D*154, buds develop from a portion of apical meristem detached in the axils of leaves during vacuolation and growth, as described by Wardlaw in *Matteuccia*[3] and found in a great number of plants[4,5] (Fig. 1). Such a detached meristem can be seen as 'shell zone'[6] quite early, in the axil of the third leaf primordium. This zone enlarges by further divisions and emerges out in the axil of the sixth primordial leaf (Fig. 3). Its further development and size are determined by time of sowing, spacing and other factors. In the non-branching varieties (Halmahera, Jap Red and Jap G) 'shell zone', active or dormant, is completely absent (Fig. 2), except in some cases, where buds develop at irregular intervals and their development is similar to those in *D*154. Unless they are stimulated to grow by insect or accidental damage to the main apex, these few buds remain inconspicuous and usually do not develop any further. Some tips do not show axillary buds at all, but the possibility of development of buds at still earlier or later stages cannot be excluded.

Extra-axillary buds develop irregularly in the three non-branching varieties, but more frequently in Halmahera. In the development of extra-axillary buds, a definite zone of detached meristem exists as usual from early stages. But some previously vacuolated cells of the axis above the axil which are in continuation with the detached meristem resume meristematic activity and are responsible for the development of bud proper (Fig. 4). In all these cases the development of provascular tissues in the bud is acropetal. The development of buds is possibly checked in the non-branching varieties by production of a sort of heteroauxin[7], which is controlled by a single recessive gene; but its expression is not complete in these varieties, as is evident from the occasional production of buds.

Details will be published elsewhere.

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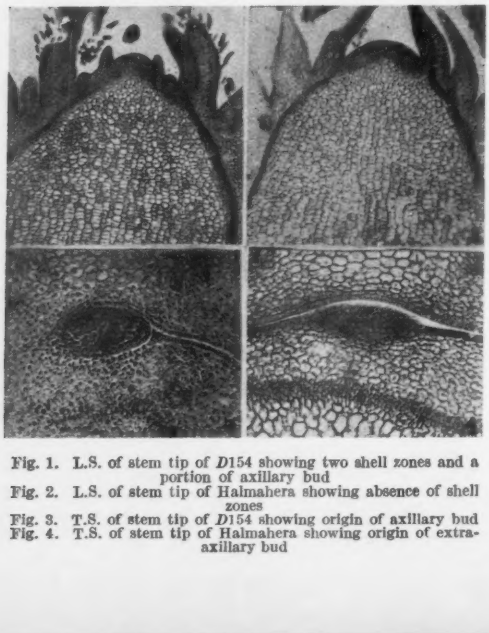


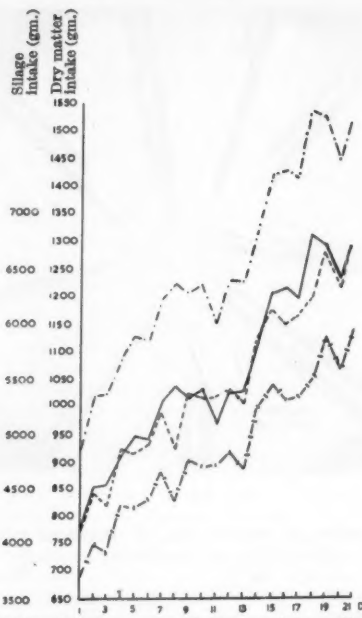
Fig. 1. L.S. of stem tip of *D*154 showing two shell zones and a portion of axillary bud
Fig. 2. L.S. of stem tip of Halmahera showing absence of shell zones
Fig. 3. T.S. of stem tip of *D*154 showing origin of axillary bud
Fig. 4. T.S. of stem tip of Halmahera showing origin of extra-axillary bud

Effect of the Percentage of Dry Matter in the Diet on the Dry-Matter Intake in Ruminants

In the course of some experiments with beef cattle, swedes and grass silage were fed, and it was observed that the appetite of the cattle, in terms of daily intake of dry matter, appeared to be inversely proportional to the percentage of moisture in these feeding-stuffs.

In order to obtain further data on this point, two sheep were fed to appetite with grass silage containing 22·66 per cent of dry matter, and a second pair of sheep received silage, from the same source, to which 300 c.c. of water had been added per kilogram of the original silage. The percentage of dry matter of this watered silage, as fed, was 16·85 per cent. All sheep were fed to appetite, and the average weight of silage eaten daily by each pair of sheep has been plotted on the accompanying graph together with the average daily dry-matter intake.

It will be noted that the weight of the daily intake of silage varied very little between the two groups of sheep, but there was a wide difference in the daily intake of dry matter, the figure being consistently higher for the sheep on the silage with a higher dry-matter percentage.



Daily intake of silage : ———, 22·66 per cent dry matter silage ; – – – –, 16·85 per cent dry matter silage.
Daily intake of dry matter : —.—., from 22·66 per cent dry matter silage ; —I—I, from 16·85 per cent dry matter silage

Although the experimental period lasted for only three weeks, these results confirm that when ruminants are fed twice daily on a diet consisting solely or mainly of succulent foods, the daily intake of dry matter is directly related to the percentage of dry matter in the diet. It follows that if ruminants are fed solely or mainly on succulent foods, maximum performance can only be expected if the dry-matter percentage of the succulent foods is maintained at a sufficiently high level to ensure that the dry-matter percentage in the diet as a whole does not fall below some critical figure—probably somewhere between 20 and 25 per cent—but this point requires further investigation.

A fuller report of this and the experiments leading up to it is in preparation for publication.

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Chromosomes of the Indian Water Buffalo

The number of chromosomes of the water buffalo (*Bubalus bubalis* L.) is a controversial issue (the names *Bubalus bubalus* L. and *B. buffelus* L. are synonyms of *B. bubalis* L.). Pchakadze[1] stated that it is $2n = 56$. Makino[2], on the contrary, reported the diploid number of chromosomes to be 48. In view of this disagreement, it was considered worth while to study the number of the Indian water buffalo.

Testicular materials, obtained by castration from 1-yr., 2½-yr. and 6-yr. old buffaloes of the Murrah breed, were fixed in Belling's modification of Nawaschin mixture, sectioned at 15 μ in thickness and stained in iodine crystal violet after overnight premordanting in 1 per cent chromic acid.

Examination revealed that the materials taken from animals aged 2½ yr. and 6 yr. were not suitable for spermatogonial chromosome count. A few good metaphase plates were, however, seen in these tissues. A large number of dividing cells were obtained in the material taken from the 1-yr. old animal. The study of the spermatogonial metaphase (Fig. 1) showed that the diploid number of chromosomes is 48. There are two types of chromosomes in respect of the position of the centromere : the first comprises four pairs with median or submedian centromere, and the second twenty pairs of rod-shaped chromosomes with terminal or nearly terminal centromere. Among the first group, there are two pairs of *J*-shaped chromosomes which are the longest in the complement. The pair next in size is also *J*-shaped, but its long arm is slightly smaller than that of the longest one, while the size of the short arm is the same as that of the longest pair. The fourth pair is a *V*-shaped one with equal arms. Among the rod-shaped chromosomes, the *X*-chromosome was found to be the longest and the *Y* seemed to be one of the smallest. Contrary to Makino, who observed that the *X*-chromosome was more deeply stained than others, no differential staining behaviour was noted in this chromosome. The number of chromosomes was also verified from the polar view of metaphase II, where there were 24 chromosomes of different sizes (Fig. 2). Our observation is in agreement with that of Makino.

(1) (2)

Fig. 1. Spermatogonial metaphase of Indian water buffalo showing $2n = 48$ chromosomes. × 2,600

Fig. 2. Second division metaphase plate (polar view). × 2,600

This work was carried out at the Animal Genetics Section, Indian Veterinary Research Institute, Izatnagar, while one of us (M. K. D.) was a member of its staff.

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Micro-forceps and Micro-scalpels

Some convenient glass micro-forceps are shown in Fig. 1. Type I are opened by their own resilience and closed by means of a tube fitting around them. In type II the reverse action is shown, closing being effected by resilience and opening by the force of a ball and rod. The two branches of the forceps are fixed in a tube of 1·5 mm. diameter, which is mounted on a de Fonbrune micromanipulator. A second tube, enclosing the first tube, can be made to

slide around the branches of the forceps, operating it by means of a piston and a syringe. The closing movement is smooth and can be controlled within the limits of a few microns. The points remain exactly opposed.

The points of type II are useful for holding very fragile objects. Type I can hold microscopical objects of various kinds, since the points can be modified to suit several purposes.

Six modifications are shown in photograph III. The points shown are, respectively, in the form of: (1) strong pincers; (2) fine pincers; (3) eyelets (Schouten type[1], diameter 7 and 20 microns, for isolating micro-organisms); (4) ball and cup (de Fonbrune type[2]); (5) a tong-like structure; and (6) pipettes (one point is filled with fluid).

The following possible applications of these forceps may be suggested: experiments on single fibres (for example, muscle, collagen, textile fibres); clamping capillaries, partly or completely; injecting two fluids in the same place; holding small quantities of different materials (for example, radioactive chemicals); micro-dissection.

Any one of the instruments illustrated can be made with the de Fonbrune microforge within a quarter of an hour.

The micro-scalpels shown in Fig. 2 are made essentially by breaking glass rods. They have cutting edges all round, the sharpness of which is generally sufficient to cut bacteria.

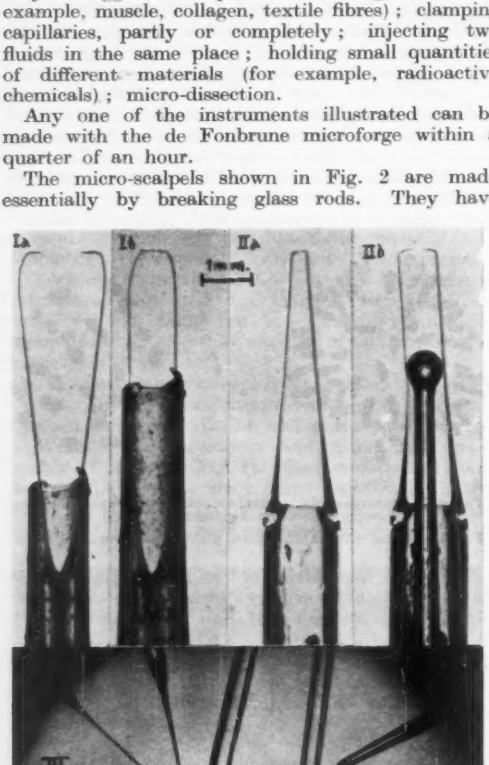

Fig. 1

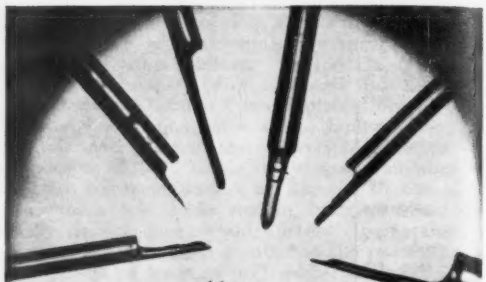

Fig. 2

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A Test for Montmorillonite

It has been shown that montmorillonite saturated with small ions, for example, lithium, is difficult to rehydrate after being dried at moderate temperatures[1-3]. This behaviour has been found to be confined to montmorillonite and forms the basis of a new test which enables the mineral to be easily distinguished from the other common montmorillonoids[4].

The hysteresis observed on drying is due to a decrease of the internal surface, which takes place in a random way and leads to the phenomenon of random inter-stratification in the re-solvated mineral. In consequence of this, the dried mineral also shows a marked decrease in exchange capacity due to the decreased rate of exchange of the interlamellar ions. The test may therefore take a number of forms, any of which may be used to identify montmorillonite.

In practice, lithium montmorillonite has been found to show the greatest effect. If the sample is either in the form of oriented flakes or powders, satisfactory saturation with lithium ions may be obtained by three washings with 3 *M* lithium chloride, the excess salt being removed with warm 80 per cent alcohol. By means of this procedure the mineral remains aggregated and the flakes retain their structure.

Lithium montmorillonite treated with glycerol, after being dried at 100° C., shows a rational series of reflexions corresponding to $d(001)$ of 17·7 kX. on X-ray analysis. If the drying is carried out at 200° C., a markedly decreased rate of uptake of glycerol is observed and the X-ray diffraction pattern shows an irrational series of reflexions that would be expected for a random mixture of spacings of 9·4 and 17·7 kX. in equal proportions[5]. Heating to 300° C. leads to a

rational series of reflexions corresponding to $d(001)$ of 9·4 kX.

Lithium montmorillonite dried at 200° C. shows a decreased exchange capacity to ammonium ions at *p*H 7, when compared with samples dried at 70° C. Wyoming bentonite showed a change from 90 m.equiv./100 gm. to 3 m.equiv./100 gm. Differential thermal analysis on lithium montmorillonite dried at 200° C. and rehydrated at 50 per cent relative humidity showed that the endothermic peak between 100° and 200° C., due to sorbed water, was greatly decreased when compared with samples dried[3] at 70° C.

These changes of internal surface on drying at 200° C. were not observed with authentic samples of beidellite (Black Jack Mine)[6], saponite (Cathkin Hill)[7], hectorite (California)[8] and two nontronites when saturated with lithium. It appears, therefore, that this decrease in internal surface takes place only when the mineral is dioctahedral and the charge in the silicate sheets is due predominantly to substitution in the octahedral layers. The test thus provides a useful method of distinguishing between the end members of the montmorillonite–beidellite series, which is a difficult procedure in the case of impure samples.

Grateful acknowledgment is made to the British Museum (Natural History), Geological Survey, and the Fullers Earth Union, Ltd., for gifts of minerals.

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Minimum Phosphate and Magnesium Requirements of Nitrifying Bacteria

The nutrient requirements of the autotrophic nitrifying bacteria are simple, but among the elements which seem to be essential for them are phosphorus and magnesium. Bömeke[1] reported that *Nitrobacter* would not grow in media from which either phosphate or magnesium was omitted; and *Nitrosomonas* would not grow in medium with magnesium omitted. Wimmer[2] found that phosphate was necessary for the growth of both organisms, but the minimum requirement was only 0·02 mgm. phosphorus per litre for both *Nitrobacter* and *Nitrosomonas*.

To find the minimum requirements of nitrifiers for these two elements, pure cultures were grown in 5-ml. liquid medium in test-tubes covered with aluminium caps. The control medium contained $M/1{,}000$ phosphate and $M/1{,}000$ magnesium sulphate. A series of transfers was made on media from which either the phosphate or the magnesium was omitted. The bacteria used were: a strain of *Nitrosomonas europæa* from Denmark[3] and a strain of *Nitrobacter winogradskii* from Ampthill, Beds[4]. A drop from a Pasteur pipette was used as the inoculum, so that the dilution at each transfer was about a hundred times.

Phosphate. The *Nitrosomonas* survived no less than eleven successive transfers on to medium with phosphate omitted; but no special steps were taken to purify the medium from every trace of phosphate, so a very small amount (too small to give the usual drop reaction for phosphate) may have been present. In any event, the amount carried over in the inoculum was very small; after three transfers, only a fraction of a microgram would be carried over. *Nitrobacter* ceased to oxidize nitrite in the second transfer, but the bacteria survived, as transfers back on the control medium were normal. On the second transfer, the theoretical amount of phosphorus carried over in the inoculum would correspond to about 0·003 mgm. per litre.

Magnesium. Both species continued to oxidize ammonia or nitrite up to the fourth successive transfer on to medium with magnesium omitted. By this transfer, the theoretical amount of magnesium carried over in the inoculum would be about 0·0002 mgm. per litre. Both species survived, as transfers back to control medium grew.

Jane Meiklejohn

Rothamsted Experimental Station,
Harpenden, Herts. June 5.

[1] Bömeke, H., *Arch. Mikrobiol.*, **14**, 63 (1949).
[2] Wimmer, G., *Z. Hyg.*, **48**, 135 (1904).
[3] Jensen, H. L., *Nature*, **165**, 974 (1950).
[4] Meiklejohn, J., *J. Gen. Microbiol.* (in the press).

Sir Jack Drummond, F.R.S.

The news of the tragic death of Sir Jack Drummond came as a severe shock to his many friends in America. Only after the initial paralysing numbness associated with the sporadic news flashes of his murder had worn off could the enormity of this crime be appreciated. Although the loss to the scientific world has been great, a deep feeling of the personal loss of a friend has been experienced by many of us in Canada. Over the years Jack Drummond has made numerous Canadians his associates. His interest and hospitality was extended to many junior men of science, and all of us will remember the impact of his personality as he blended the science of nutrition and the art of entertainment into a formula as palatable as his Englishman's food. Perhaps no one has done so much to help so many Canadian medical research students attain a balanced perspective of scientific life in England. To many of us the pleasure of informal evenings, and the charm of Drummond as a host, will remain as our most vivid memory of a man who was truly more than a great man of science.

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FORTHCOMING EVENTS

Tuesday, December 30—Friday, January 2

Science Masters' Association (in the Chemistry Department, Royal College of Science, Imperial Institute Road, London, S.W.7).—Annual Meeting: "Science in the Service of the Community".

Friday, January 2

Institution of Mechanical Engineers (joint meeting with the Industrial Administration and Engineering Production Group, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Capt. G. C. Adams: "Principles and Practice Governing Interchangeability and the Specification of Manufacturing Limits of Size as influenced by Statistical Considerations".

APPOINTMENTS VACANT

Senior Lecturer in Physics and a Senior Lecturer in Physical Chemistry (with a good honours degree in physics or chemistry respectively and, if possible, experience in teaching, industry and research)—The Principal, Acton Technical College, High Street, Acton, London, W.3 (January 3).

Lecturer in Physiology—The Registrar, The Medical School, Birmingham 15 (January 10).

Graduate (male) in Botany or Agriculture in the Technical Advisory Section—The Director, Sports Turf Research Institute, St. Ives Research Station, Bingley, Yorks (January 15).

Senior Organic Chemist to the Division of Biochemistry and General Nutrition, C.S.I.R.O., at the central laboratories in the University of Adelaide, to work on general problems involved in the introduction of isotopic carbon, nitrogen, etc., into organic compounds—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment 4078 (January 17).

Chair of Fuel Technology—The Registrar, The University, Sheffield (January 31).

Lecturer in Biochemistry—The Secretary, Queen's University, Belfast (February 25).

Assistant Experimental Officers in the Instrumentation Department of the Royal Aircraft Establishment, Farnborough, for design and development of equipment for measurements in aeronautical research: Electrical Engineer or Physicist for work on electronic circuits, and an Electrical or Mechanical Engineer for work on electro-mechanical instruments—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.472/52A.

Assistant Lecturer (Grade B) in Chemistry at the Wolverhampton and Staffordshire Technical College—The Clerk to the Joint Education Committee, Education Offices, North Street, Wolverhampton.

Head of the Science Department of the Ewell Technical College—The Chief Education Officer, County Hall, Kingston-upon-Thames, Surrey.

Physical Chemist (with research experience) to investigate certain biophysical aspects of flour milling, and a Chemist for research on flour quality—The Director, Research Association of British Flour Millers, Cereals Research Station, Old London Road, St. Albans, Herts.

Physicist or Engineer in the Instruments and Air Photography Division of the Royal Aircraft Establishment, Farnborough, for research and development on analogue computers, servo-mechanisms and similar precision electro-mechanical equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.312/52A.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Communications of the Dublin Institute for Advanced Studies Series A, No. 9: Jump Conditions at Discontinuities in General Relativity. By Stephen O'Brien and John L. Synge. Pp. 20. (Dublin: Dublin Institute for Advanced Studies, 1952.) [311

Department of Scientific and Industrial Research. Report of the Radio Research Board with the Report of the Director for Radio Research for the Year 1951. Pp. iv+36. (London: H.M. Stationery Office, 1952.) 1*s.* 6*d.* net. [311

Fire Protection Association. Technical Booklet No. 11: A Comparison of the Extinguishing Effects of Chlorobromomethane, Methyl Iodide and Carbon Tetrachloride. By E. H. Coleman. Pp. 12. (London: Fire Protection Association, 1952.) [311

Instruments and Accessories for Radio-Isotope Applications. Edited by Dr. Denis Taylor and A. G. Peacock. Second edition. Pp. 20. (London: Scientific Instrument Manufacturers' Research Association, 1952.) Free. [311

Manchester Municipal College of Technology. Jubilee Year 1952: an Account of the Origin of the College and its Development since the Opening of the Present Building in 1902. Pp. iv+36. (Manchester: Municipal College of Technology, 1952.) [411

Atomic Energy Research Establishment. Lecture Notes on Pile Theory: an A.E.R.E. Lecture. By C. A. Rennie. (R/L.5.) Pp. ii+29+3 plates. 5*s.* net. A Quantitative Study of Uranium-Graphite Lattices: an A.E.R.E. Report. By E. A. Guggenheim and M. H. L. Pryce. (R/R.922.) Pp. ii+28+12 plates. 6*s.* net. (London: H.M. Stationery Office, 1952.) [411

Colonial Office. Colonial Research Publications, No. 13: Land Registration. By Sir Ernest Dowson and V. L. O. Sheppard. Pp. xi+212. (London: H.M. Stationery Office, 1952.) 25*s.* net. [611

General Register Office—General Registry Office, Scotland. Census 1951, Great Britain, One Per Cent Sample Tables. Part 2: Characteristics and Composition of Private Households, Non-Private Households, Education, Birthplace and Nationality, Fertility, Welsh and Gaelic Languages, Conurbation Supplement. Pp. viii+161–367+xviii. (London: H.M. Stationery Office, 1952.) 40*s.* net. [611

Experimental and Research Station, Cheshunt. Annual Report (thirty-seventh Year), 1951. Pp. 96+6 plates. (Cheshunt: Nursery and Market Garden Industries' Development Society, 1952.) [1111

Other Countries

Smithsonian Institution: Institute of Social Anthropology. Publication No. 13: The Tajin Totonac. By Isabel Kelly and Angel Palerm. Part 1: History, Subsistence, Shelter and Technology. Pp. xiv+369+33 plates. (Washington, D.C.: Government Printing Office, 1952.) 2.75 dollars. [2110

Sugar Research Foundation. Scientific Report Series No. 14: Modern Trends in Infant Nutrition and Feeding. By Dr. Jonathan T. Lanman. Pp. 96. (New York: Sugar Research Foundation, Inc., 1952.) Free. [2110

Uganda Protectorate. Annual Report of the Forest Department for the Year ended 31st December 1951. Pp. iv+38. (Entebbe: Government Printer, 1952.) 2*s.* [2210

Bulletin of the Museum of Comparative Zoology. Vol. 107, No. 3: The Carabid Beetles of New Guinea, Part 2, The Agonini. By P. J. Darlington, Jr. Pp. 87–252+4 plates. (Cambridge, Mass.: Harvard College, 1952.) [2210

Ceylon. Part 4: Education, Science and Art(E). Administration Report of the Director of National Museums, Ceylon, for 1951. By P. E. P. Deraniyagala. Pp. E.24+1 plate. (Colombo: Government Publications Bureau, 1952.) 55 cents. [2310

Symposium on Physiological Effects of Radiation at the Cellular Level, given at a Research Conference for Biology and Medicine of the Atomic Energy Commission. Sponsored by the Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, April 12–13, 1951. Pp. 233. (Philadelphia: Wistar Institute of Anatomy and Biology, 1952.) [2710

Indian Forest Bulletin. No. 159: Indigenous Cellulosic Raw Materials for the Production of Pulp, Paper and Board, Part 9, Newsprint Grade Mechanical Pulp from *Sterculia companulata* (*papita*). By Dr. R. V. Bhat and K. C. Virmani. Pp. ii+7. (Delhi: Manager of Publications, 1952.) 9 annas; 10*d.* [3010

Proceedings of the Rajasthan Academy of Sciences. Special issue: Does Sambhar Lake owe its Salt to the Rann of Cutch? By Dr. N. N. Godbole. Pp. vii+57. (Pilani: Rajasthan Academy of Sciences, 1952.) 2 rupees. [3010

General Technical Department T.N.O. of the Central National Council for Applied Scientific Research in the Netherlands. Report T.A. 270: Survey of Water Desalting Investigations, in particular the Electro-dialytic Method. By Dr. Y. Boer-Nieveld and D. Pauli. Pp. 170. (The Hague: General Technical Department, T.N.O., 1952.) 18.75 fl. [311

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Ecological Crop Geography and Field Practices of the Ryukyu Islands, Natural Vegetation of the Ryukyus, and Agro-Climatic Analogues in the Northern Hemisphere. By M. Y. Nuttonson. Pp. 106. (Washington, D.C.: American Institute of Crop Ecology, 1952.) [311

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Fiskeridirektoratets Skrifter. Serie Havundersøkelser, Vol. 10, No. 2: The Leisterfjord Herring and its Environment. By Olav Aasen. Pp. 63+3 plates. (Bergen: A/s John Griegs Boktrykkeri, 1952.) [511

Kungl. Svenska Vetenskapsakademiens Handlingar. Fjärde Serien, Band 2, No. 6: Étude complémentaire des Poissons de l'Eotrias de Madagascar. Par Jean-Pierre Lehman. Pp. 201+48 plates. (Stockholm: Almquist and Wiksell; London: H. K. Lewis and Co., Ltd., 1952.) 75 kr. [611

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